

TITLE: DRIVE DEVICE

INVENTOR: TADASHI NAKAMURA

TECHNICAL FIELD

[0001] The present invention relates to a drive apparatus for recording data in an information recording media and for reproducing data recorded in the information recording media.

BACKGROUND ART

[0002] Recently, various types of information recording mediums are used to record digital data. For example, a rewritable optical disc or a write-once optical disc is used. In the rewritable optical disc, data can be rewritten repeatedly at the same location. In the write-once optical disc, data can be written only once at the same location, while it is inexpensive.

[0003] As an example of rewritable optical discs, there are DVD-RAM discs and BD-RE (Blu-ray Disc Rewritable) discs and the like.

[0004] As an example of write-once optical discs, there are DVD-R discs and BD-R (Blu-ray Disc Recordable) discs and the like.

[0005] In the rewritable optical disc, a defective management mechanism is introduced to improve the reliability of data recorded on the disc.

[0006] The defective management mechanism includes a slipping replacement algorithm and a linear replacement algorithm.

[0007] The slipping replacement algorithm is mainly performed when the disc is formatted. In the slipping replacement algorithm, all of the ECC clusters in the user data area are checked for detecting a defective cluster. When the defective cluster is found, the location of the defective cluster is registered to a primary defect list (hereinafter, "PDL"). The logical cluster corresponding to the defective cluster is

shifted such that the logical cluster corresponds to a physical cluster which is next to the physical cluster corresponding to the defective cluster.

[0008] Thus, when the user data is recorded, it is possible to avoid recording the user data in the defective cluster registered in the PDL. As a result, it is possible to improve the reliability of the data recording.

[0009] The linear replacement algorithm is performed when a user data is recorded.

[0010] After the user data is recorded, a verify process is performed. In the verify process, the recording result is verified. If the data recording has failed, the ECC cluster including the recording location is determined as a defective cluster. Then, the location of the defective cluster is managed by a secondary defect list (hereinafter, "SDL").

[0011] The user data is recorded in the spare area which is located at the inner-most periphery or the outer-most periphery on the disc, instead of the defective cluster in the user data area.

[0012] The verify process described above is performed during the replacement recording. If the data recording has succeeded, the location at which the user data is recorded is determined. An SDL entry which correlates the location of the defective cluster with an ECC cluster for replacement is generated. Then, the SDL entry is registered to the SDL.

[0013] The SDL entry is provided for each of the all ECC clusters included in the spare area. It is possible to manage whether or not each ECC cluster in the spare area is available as a replacement cluster. If the ECC cluster is an unrecorded area in the spare area, then the ECC cluster is available as a replacement cluster. If the ECC cluster is a recorded area in the spare area, then the ECC cluster is not

available as a replacement cluster. The unrecorded area in the spare area is also called a spare cluster.

[0014] In the reproduction process, by referring to the PDL and the SDL, if necessary, the data is reproduced from the replacement cluster.

[0015] The PDL and the SDL are recorded in a defect management area (hereinafter, "DMA") provided in the lead-in area on the disc. In the DMA, information indicating the size of the spare area and the like is further recorded.

[0016] In the rewritable optical disc, the information on the defective management is updated by rewriting the DMA.

[0017] In the write-once optical disc, it is possible to introduce a defective management mechanism, for example, as described in the specification of U.S. laid-open patent publication No. 2004/0076096 (hereinafter, "reference 1").

[0018] FIG. 3 of the reference 1 shows a data structure of the disc. In the disc of the reference 1, the DMA is provided in the lead-in area and the lead-out area.

[0019] Further, a temporary defect management area (hereinafter, "TDMA") is provided in the lead-in area and the lead-out area.

[0020] In the write-once optical disc, the information on the defective management is updated by additionally recording defective information in the TDMA each time the defective information is updated.

[0021] When the disc is closed or finalized, the data in the latest TDMA is recorded in the DMA.

[0022] In the TDMA, temporary defect management information (hereinafter, "TDDS") and temporary defect information (hereinafter, "TDFL") are recorded.

- [0023] FIG. 5B of the reference 1 shows a data structure of the TDDS. The TDDS includes pointer information to the TDFL. The TDFL can be recorded in the TDMA a plurality of times. The pointer information is recorded for the respective TDFLs.
- [0024] In the TDDS, a last recorded address on the write-once optical disc is recorded. As shown in FIG. 5B of the reference 1, a single write-once optical disc can have a plurality of last recorded addresses.
- [0025] In the TDDS, a last recorded replacement address on the write-once optical disc is recorded. As shown in FIG. 5B of the reference 1, a single write-once optical disc can have a plurality of last recorded replacement addresses.
- [0026] FIG. 6 of the reference 1 shows a data structure of the TDFL.
- [0027] The TDFL includes information regarding defect #1, #2, ... and the like.
- [0028] The information regarding defect includes status information, a pointer to the defective cluster and a pointer to the replacement cluster.
- [0029] The information regarding defect has a data structure similar to the SDL entry included in the SDL. The information regarding defect performs a function similar to the SDL entry.
- [0030] Figures 33A and 33B show a method for updating the TDFL disclosed in FIG. 9A and FIG. 9B of the reference 1.
- [0031] Figure 33A shows a data structure of the TDFL #0. The TDFL #0 includes the information regarding defect #1, #2 and #3 corresponding to the defects #1, #2 and #3.
- [0032] After the TDFL #0 is recorded, it is assumed that the defects #4 and #5 are detected as a result of performing a new data recording. In this case, the TDFL #1 shown in Figure 33B is recorded on the write-once optical disc.

- [0033] The TDFL #1 is generated by maintaining the information regarding defect #1, #2 and #3 included in the TDFL #0 and adding the information regarding defect #4 and #5 corresponding to the defects #4 and #5.
- [0034] FIG. 10 of the reference 1 shows a data structure of the information regarding defect.
- [0035] The information regarding defect includes status information. The status information includes information indicating that the defective area is a continuous defect block or a single defect block.
- [0036] The information regarding defect further includes a pointer to the defective area (the location of the defective area on the disc).
- [0037] The information regarding defect further includes a pointer to the replacement area corresponding to the defective area.
- [0038] When the defective area is a continuous defect block, the status information indicates that a pointer to the defective area designates a start location of the continuous defect block or an end location of the continuous defect block. In this case, the status information further indicates that a pointer to the replacement area designates a start location of the replacement block or an end location of the replacement block.
- [0039] By using these data structures, the defective management mechanism can be implemented in the write-once optical disc.
- [0040] Further, by using the defective management mechanism described above, it is possible to implement a pseudo-overwrite recording for the write-once optical disc.
- [0041] With reference to Figures 31 and 32, the pseudo-overwrite recording for the write-once optical disc will be described.

[0042] As described above, in the defective management mechanism, by using the replacement information such as the information regarding defect or the SDL entry, the physical address at which the data is actually recorded is mapped to another location which is previously allocated, without changing the logical address at which the data is recorded.

[0043] When it is instructed to record data at a logical address at which the data has already been recorded on the write-once optical disc, the data is recorded in a sector located at a physical address which is different from the physical address corresponding to the logical address, and the replacement information is updated to maintain the logical address. According to this process, it is possible to overwrite data in a pseudo manner. Hereinafter, such data recording is referred to as a pseudo-overwrite recording.

[0044] Figure 31 shows a data structure after directories and files are recorded in the information recording medium 1 which is a write-once optical disc. In the state shown in Figure 31, it is assumed that the pseudo-overwrite recording has not been performed.

[0045] In the write-once optical disc, the user data area on the disc is managed as a unit of track or session.

[0046] In Figure 31, the user data recorded in the user data area is managed by a file system. A space managed by the file system is referred to as a volume space 2.

[0047] In the description below, it is assumed that information recorded in the information recording medium 1 as the volume/file structure of the file system (e.g. descriptor, pointer, metadata partition and metadata file) has a data structure defined in the ISO/IEC 13346 standard or the UDF (Universal Disc Format) specification, unless it is explicitly described on the contrary.

[0048] In Figure 31, a volume structure area 3 and a physical partition 4 are recorded in the volume space 2.

[0049] In the physical partition 4, metadata partitions 5a, 5b defined by version 2.5 of the UDF specification are included.

[0050] In the physical partition 4, metadata file 6a and metadata mirror file 6b which is the duplication of the metadata file 6a are recorded.

[0051] FE (metadata file) 7a and FE (metadata mirror file) 7b, each being a file entry (FE) indicating the recording location in the physical partition 4, are recorded. Further, data file (File-a) 8 and data file (File-b) 9 are also recorded.

[0052] All information on the file structure such as a file entry and directory file is allocated in the metadata partition, i.e. the metadata file.

[0053] In the data structure defined in the UDF specification, the respective recording locations of the metadata partition 5a and the file set descriptor (FSD) 12 are recorded in the volume structure area 3.

[0054] By retrieving the file structure from the ROOT directory using the FSD 12 as a start point, it is possible to access data file (File-a) 8, for example.

[0055] Next, in the state shown in Figure 31, it is assumed that the pseudo-overwrite recording for data file (File-c) is performed.

[0056] Figure 32 shows a data structure after the pseudo-overwrite recording for data file (File-c) is completed.

[0057] Herein, it is assumed that the data file (File-c) is recorded immediately under the ROOT directory on the information recording medium 1.

[0058] During recording the data file (File -c), the required information on the file structure is updated or generated in order to add the data file (File-c). Specifically, FE (ROOT) 13 is updated and FE (File-c) 14 is generated, for example.

[0059] The data file (File-c) 15 is recorded in an unrecorded area shown in Figure 31. Figure 32 shows a state at this time.

[0060] When the FE (File-c) 14 is recorded, the FE (File-c) 14 is recorded in the unrecorded area 11a in the metadata partition 5a (i.e. the metadata file 6a).

[0061] Next, the pseudo-overwrite recording is performed as if the FE (ROOT) 16 would be overwritten on the FE (ROOT) 13.

[0062] In this case, as shown in Figure 32, the data for the FE (ROOT) 16 is recorded in the spare area 17.

[0063] Further, the replacement information included in the disc management information 2 is updated such that the FE (ROOT) 13 is mapped to the FE (ROOT) 16.

[0064] After performing the recording process for files, a reproduction operation for reproducing the data file (File-c) 15 will be described.

[0065] The location information of FE (metadata file) 7a and the location information of FSD 12 are obtained from the volume structure area 3 of the information recording medium 1.

[0066] Next, the file structure is reproduced. In order to reproduce the file structure, the FSD 12 is reproduced based on the location information of FE (metadata file) 7a and the location information of FSD 12.

[0067] The location information of the FE (ROOT) 13 is obtained as a logical address from the reproduced FSD 12.

[0068] The FE (ROOT) 13 is reproduced based on the location information of the FE (ROOT) 13.

[0069] By referring to the replacement information, the FE (ROOT) 16, to which the FE (ROOT) 13 is mapped, is reproduced.

- [0070] The FE (ROOT) 16 includes the latest ROOT directory file. Accordingly, the FE (ROOT) 16 includes the location information of the FE (File-c) 14.
- [0071] The data file (File-c) 15 is reproduced using the location information of the data file (File-c) 15 which is obtained from the FE (File-c) 14.
- [0072] Thus, in the write-once optical disc, it is possible to perform a pseudo-overwrite recording using the defective management mechanism.
- [0073] However, according to the pseudo-overwrite recording for the write-once optical disc described above, there is a problem that if there is no unrecorded area in the spare area, it is not possible to further perform the data recording even if there is an unrecorded area in the user data area. This is because it is not possible to update file system information.
- [0074] In particular, in the write-once optical disc, the size of the spare area is fixed at the time when the disc is formatted (initialized), unlike the rewritable optical disc in which the size of the spare area can be extended if required.
- [0075] It is difficult to determine the size of the spare area appropriately in view of the pseudo-overwrite recording which may be performed in the future.
- [0076] If the size of the spare area is determined as a relatively large size, the size of the user data area must be reduced. If the size of the spare area is determined as a relatively small size, a problem may be caused. The problem is that it is not possible to further perform the data recording even if there is an unrecorded area in the user data area. In either case, it is not possible to effectively utilize the user data area of the write-once optical disc.
- [0077] The present invention is intended to solve the problem described above. One of the purposes of the present invention is to provide a drive apparatus capable

of utilizing the user data area without any loss in the pseudo-overwrite recording for the write-once optical disc.

[0078] According to the present invention, it is possible to provide a drive apparatus capable of utilizing the user data area without any loss in the pseudo-overwrite recording for the write-once optical disc.

DISCLOSURE OF THE INVENTION

[0079] According to one aspect of the invention, a drive apparatus is provided for performing a pseudo-overwrite recording for a write-once recording medium, wherein the write-once recording medium includes a spare area and a user data area, at least one track are allocated in the user data area. The drive apparatus includes: a recording/reproduction section for performing a recording operation or a reproduction operation for the write-once recording medium; and a drive control section for controlling the recording/reproduction section, wherein the drive control section performs a process including: receiving a recording instruction including a location at which data is to be recorded; determining a track among at least one tracks corresponding to the location included in the recording instruction; controlling the recording/reproduction section to record data at a replacement location in the user data area instead of the location included in the recording instruction; determining whether or not the recording of the data at the replacement location in the user data area has succeeded; and when the recording of the data at the replacement location in the user data area has failed, controlling the recording/reproduction section to record the data at a location in the spare area.

[0080] In one embodiment of the invention, the drive control section performs a process further including: determining whether or not the recording of the data at the location in the spare area has succeeded; and when the recording of the data at the

location in the spare area has failed, controlling the recording/reproduction section to record the data in the spare area until the recording of the data in the spare area has succeeded.

[0081] In one embodiment of the invention, the determined track is an open track.

[0082] In one embodiment of the invention, the determined track is a closed track having an unrecorded area.

[0083] According to another aspect of the invention, a drive apparatus is provided for performing a pseudo-overwrite recording for a write-once recording medium, wherein the write-once recording medium includes a spare area and a user data area. The drive apparatus includes: a recording/reproduction section for performing a recording operation or a reproduction operation for the write-once recording medium; and a drive control section for controlling the recording/reproduction section, wherein the drive control section performs a process including: generating replacement management information including an original location and a replacement location; and controlling the recording/reproduction section to record the replacement management information in the write-once recording medium, wherein: when the replacement for the purpose of the pseudo-overwrite recording occurs, the drive control section sets a first range of value to the replacement location of the replacement management information; and when the replacement for the purpose of recording due to defect occurs, the drive control section sets a second range of value to the replacement location of the replacement management information.

[0084] In one embodiment of the invention, the first range is a range of the user data area, and the second range is a range of the spare area.

BRIEF DESCRIPTION OF THE DRAWINGS

[0085] Figure 1A is an illustrative diagram showing an appearance of information recording medium 100 according to an embodiment of the present invention.

[0086] Figure 1B is an illustrative diagram showing an exemplary data structure of the information recording medium 100 according to an embodiment of the present invention.

[0087] Figure 1C is an illustrative diagram showing an exemplary data structure of the user data area 108 shown in Figure 1B.

[0088] Figure 2A is an illustrative diagram showing an exemplary data structure of the session management information 200 according to an embodiment of the present invention.

[0089] Figure 2B is an illustrative diagram showing an exemplary data structure of the track management information 210 according to an embodiment of the present invention.

[0090] Figure 2C is an illustrative diagram showing an exemplary data structure of the space bitmap management information 220 according to an embodiment of the present invention.

[0091] Figure 3 is an illustrative diagram showing an exemplary data structure of the disc structure information 1110 according to an embodiment of the present invention.

[0092] Figure 4 is an illustrative diagram showing an exemplary data structure of the information recording medium 100b according to an embodiment of the present invention.

[0093] Figure 5A is an illustrative diagram showing an exemplary data structure of the replacement management information list 1000 according to an embodiment of the present invention.

[0094] Figure 5B is an illustrative diagram showing an exemplary data structure of the replacement management information 1010 according to an embodiment of the present invention.

[0095] Figure 6 is a block diagram showing an exemplary configuration of the information recording/reproduction apparatus 300 according to an embodiment of the present invention.

[0096] Figure 7 is an illustrative diagram showing an exemplary data structure of the information recording medium after the formatting process according to an embodiment of the present invention.

[0097] Figure 8A is a flowchart showing a recording process according to an embodiment of the present invention.

[0098] Figure 8B is a flowchart showing a RMW process according to an embodiment of the present invention.

[0099] Figure 9 is an illustrative diagram showing an exemplary data structure of the information recording medium after the recording process according to an embodiment of the present invention.

[00100] Figure 10 is a flowchart showing a reproduction process according to an embodiment of the present invention.

[00101] Figure 11 is an illustrative diagram showing an exemplary data structure of the replacement management information 1010B according to an embodiment of the present invention.

- [00102] Figure 12 is an illustrative diagram showing an exemplary data structure of the physical address space and the logical address space according to an embodiment of the present invention.
- [00103] Figure 13A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00104] Figure 13B is an illustrative diagram showing a replacement management information according to an embodiment of the present invention.
- [00105] Figure 14A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00106] Figure 14B is an illustrative diagram showing a replacement management information according to an embodiment of the present invention.
- [00107] Figure 15A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00108] Figure 15B is an illustrative diagram showing a replacement management information according to an embodiment of the present invention.
- [00109] Figure 16A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00110] Figure 16B is an illustrative diagram showing a replacement management information according to an embodiment of the present invention.
- [00111] Figure 17A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00112] Figure 17B is an illustrative diagram showing a replacement management information according to an embodiment of the present invention.

- [00113] Figure 18 is an illustrative diagram showing an exemplary data structure of the DFL entry 2010 which is an example of the replacement management information according to an embodiment of the present invention.
- [00114] Figure 19A is a flowchart showing a recording process according to an embodiment of the present invention.
- [00115] Figure 19B is a flowchart showing a recording process according to an embodiment of the present invention.
- [00116] Figure 20A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00117] Figure 20B is an illustrative diagram showing a replacement management information according to an embodiment of the present invention.
- [00118] Figure 21A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00119] Figure 21B is an illustrative diagram showing a replacement management information according to an embodiment of the present invention.
- [00120] Figure 22A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00121] Figure 22B is an illustrative diagram showing a replacement management information according to an embodiment of the present invention.
- [00122] Figure 23A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00123] Figure 23B is an illustrative diagram showing a replacement management information according to an embodiment of the present invention.
- [00124] Figure 24A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.

- [00125] Figure 24B is an illustrative diagram showing a replacement management information according to an embodiment of the present invention.
- [00126] Figure 25 is an illustrative diagram showing an exemplary data structure of the track management information according to an embodiment of the present invention.
- [00127] Figure 26A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00128] Figure 26B is an illustrative diagram showing a replacement management information according to an embodiment of the present invention.
- [00129] Figure 27 is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00130] Figure 28 is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00131] Figure 29 is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00132] Figure 30 is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00133] Figure 31 is an illustrative diagram showing an exemplary data structure of the information recording medium according to the conventional technique.
- [00134] Figure 32 is an illustrative diagram showing an exemplary data structure of the information recording medium after the file recording process according to the conventional technique.
- [00135] Figure 33A is an illustrative diagram showing an exemplary data structure of the TDFL according to the conventional technique.

- [00136] Figure 33B is an illustrative diagram showing an exemplary data structure of the TDFL according to the conventional technique.
- [00137] Figure 34 is a flow chart showing a recording process according to an embodiment of the present invention.
- [00138] Figure 35A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00139] Figure 36A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00140] Figure 37A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00141] Figure 37B is an illustrative diagram showing replacement management information according to an embodiment of the present invention.
- [00142] Figure 38A is an illustrative diagram related to replacement recording according to an embodiment of the present invention.
- [00143] Figure 38B is an illustrative diagram related to replacement management information according to an embodiment of the present invention.
- [00144] Figure 39A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00145] Figure 39B is an illustrative diagram showing replacement management information according to an embodiment of the present invention.
- [00146] Figure 40A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00147] Figure 41A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.

- [00148] Figure 41B is an illustrative diagram showing replacement management information according to an embodiment of the present invention.
- [00149] Figure 42A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00150] Figure 42B is an illustrative diagram showing replacement management information according to an embodiment of the present invention.
- [00151] Figure 43 is a flowchart showing a recording process according to an embodiment of the present invention.
- [00152] Figure 44A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00153] Figure 45A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00154] Figure 45B is an illustrative diagram showing replacement management information according to an embodiment of the present invention.
- [00155] Figure 46A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00156] Figure 46B is an illustrative diagram showing replacement management information according to an embodiment of the present invention.
- [00157] Figure 47 is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00158] Figure 48 is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.
- [00159] Figure 49A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.

[00160] Figure 50A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.

[00161] Figure 51A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.

[00162] Figure 51B is an illustrative diagram showing replacement management information according to an embodiment of the present invention.

[00163] Figure 52A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.

[00164] Figure 52B is an illustrative diagram showing replacement management information according to an embodiment of the present invention.

[00165] Figure 53A is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.

[00166] Figure 53B is an illustrative diagram showing replacement management information according to an embodiment of the present invention.

[00167] Figure 54 is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.

[00168] Figure 55 is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.

[00169] Figure 56 is an illustrative diagram showing a replacement recording according to an embodiment of the present invention.

[00170] 100, 100b information recording medium

[00171] 101 lead-in area

[00172] 102, 102a data area

[00173] 103 lead-out area

[00174] 103b, 103c outer area

[00175]	104, 105	disc management information area
[00176]	104a, 105a	disc management information area
[00177]	106, 106a	inner spare area
[00178]	107, 107a	outer spare area
[00179]	108, 108a	user data area
[00180]	109	volume space
[00181]	122	unrecorded area
[00182]	120, 121	LRA
[00183]	210	track management information
[00184]	211	session start information
[00185]	212	track start location information
[00186]	213	last recorded address information within track (LRA)
[00187]	300	information recording/reproduction apparatus
[00188]	301	system control section
[00189]	302	memory circuit
[00190]	303	I/O bus
[00191]	304	magnetic disc apparatus
[00192]	310	drive apparatus
[00193]	311	drive control section

BEST MODE FOR CARRYING OUT THE INVENTION

[00194] (Embodiment 1)

[00195] 1-1. Write-once recording medium

[00196] Figure 1A shows an appearance of information recording medium 100 according to an embodiment of the present invention.

[00197] A lead-in area 101 is located in an inner-most periphery of the information recording medium 100. A lead-out area 103 is located in an outer-most periphery of the information recording medium 100. A data area 102 is located between the lead-in area 101 and the lead-out area 103 of the information recording medium 100.

[00198] In the lead-in area 101, reference information necessary for an optical pickup included in the recording/reproduction section 314 which will be described below to access the information recording medium 100, information for identifying from other recording media, and the like are recorded. In the lead-out area 103, similar information as those in the lead-in area 101 is recorded.

[00199] A plurality of physical sectors are assigned to the lead-in area 101, the data area 102 and the lead-out area 103. Each physical sector is a minimum access unit. Each physical sector is identified by an address information such as a physical sector number (hereinafter, "PSN").

[00200] The data recording/reproduction is performed for each ECC cluster (or each ECC block) including a plurality of physical sectors. An ECC cluster (or an ECC block) is a minimum unit for the data recording/reproduction.

[00201] Figure 1B shows a data structure of the information recording medium 100. In Figure 1B, the lead-in area 101, the data area 102 and the lead-out area 103 are shown in a lateral arrangement, although they are actually arranged in a concentric circular manner as shown in Figure 1A.

[00202] The lead-in area 101 includes a disc management information area 104. The lead-out area 103 includes a disc management information area 105. Disc management information is recorded in each of the disc management information areas 104 and 105. The disc management information includes replacement

management information, session management information, and space bitmap management information. This information will be described below. The disc management information areas 104 and 105 are used as an area for updating the disc management information. The area for updating the disc management information is also referred to as a temporal disc management information area.

[00203] In a case where the present invention is applied to the BD-R specification, the term "disc management information area" in the present specification should be read as a "Disc Management Area (DMA)", the term "temporal disc management information area" in the present specification should be read as a "Temporal Disc Management Area (TDMA)", the term "disc management information" in the present specification should be read as a "Disc Management Structure (DMS)" and the term "temporal disc management information" in the present specification should be read as a "Temporal Disc Management Structure (TDMS)".

[00204] The data area 102 includes an inner spare area 106, a user data area 108 and an outer spare area 107.

[00205] The user data area 108 is an area used for recording a user data.

[00206] Figure 1C shows a data structure of the user data area 108.

[00207] The user data area 108 includes a plurality of sessions. Each session includes a plurality of tracks.

[00208] Each track is a contiguous area on the information recording medium 100. Each track is managed by track management information which will be described below.

[00209] In a case where the present invention is applied to the BD-R specification, the term "track" in the present specification should be read as a "Sequential Recording Range" (hereinafter, "SRR").

- [00210] Each session includes a plurality of tracks which are contiguously allocated on the information recording medium 100. Each session is managed by session management information which will be described below.
- [00211] Figure 2A shows a data structure of the session management information 200 for managing the session. The session management information 200 is included in the disc management information.
- [00212] The session management information 200 includes header information 201 and a plurality of track management information.
- [00213] The header information 201 includes general information such as an identifier of the session management information 200 and the number of the track management information 210 shown in Figure 2B.
- [00214] The track management information #N contains information corresponding to the track #N shown in Figure 1C, where N denotes an integer greater than or equal to 1.
- [00215] Figure 2B shows a data structure of the track management information 210 for managing the track. The track management information 210 is included in the disc management information.
- [00216] The track management information 210 includes session start information 211 which indicates whether or not the track is a leading track of the session, track start location information 212 which indicates a start location of the track, and last recorded address information within track 213 which indicates a location at which data has been lastly recorded within the track. Hereinafter, the last recorded address information within track 213 is referred to as LRA 213.
- [00217] If the track managed by the track management information is 210 located at a leading position of the session, a value (e.g. "1") indicating that the track is located

at a leading position of the session is set to session start information 211. Otherwise, a different value (e.g. "0") is set to session start information 211.

[00218] The track start location information 212 includes a physical address indicating a start location of the track.

[00219] The LRA 213 includes a physical address indicating a location at which valid data has been lastly recorded within the track. Valid data maybe, for example, user data supplied from the host apparatus 305. The LRA 120 and the LRA 121 shown in Figure 1C are an example of the LRA 213.

[00220] In the case where the present invention is applied to the BD-R specification, the term "track management information" in the present specification should be read as a "Sequential Recording Range Entry (SRR Entry)" and the term "session management information" in the present specification should be read as a "Sequential Recording Range Information".

[00221] In the case where the data recording is performed for each ECC cluster as a minimum unit on the information recording medium 100, the location indicated by the LRA 213 does not always match the boundary of ECC clusters.

[00222] In general, the size of data specified by the recording instruction does not match multiple integral of the size of one ECC cluster. In this case, the LRA 213 indicates an address of the last physical sector among the physical sectors in which the data specified by the recording instruction is recorded.

[00223] If the location indicated by the LRA 213 does not match the boundary of ECC clusters, padding data is recorded after the valid data so that the end of the recorded data can match the boundary of ECC clusters.

[00224] In the present embodiment, the data recording can be performed for each track. In this case, the recording of new data is started from a leading position of

each track, and the new data is contiguously recorded within the track (a sequential recording). When the data recording is performed for a track, the location at which the data has been lastly recorded within the track is reflected to the LRA 213.

[00225] When the data recording is re-started within the track, a value of the LRA 213 is checked. By checking the value of the LRA 213, it is possible to determine a next writable address within the track.

[00226] In the case where no data is recorded within the track (e.g. immediately after the track is allocated), a predetermined value (e.g. "0") indicating such a status can be set to the LRA 213.

[00227] In general, a next writable address (hereinafter, "NWA") indicates a location of a physical sector which is next to the physical sector indicated by the LRA 213. Alternatively, in the case where the data recording is performed for each ECC cluster as a minimum unit on the information recording medium 100, the NWA indicates a location of a leading position of an ECC cluster which is next to the ECC cluster including the physical sector indicated by the LRA 213.

[00228] The location of the NWA is calculated according to Expression (1) below.

[00229] (a) When $LRA \neq 0$

$$NWA = N \times (\text{Floor}(LRA / N) + 1)$$

N: the number of the physical sectors included in each ECC cluster (for example, $N = 32$).

[00230] (b) When $LRA = 0$

$$NWA = (\text{start location of the corresponding track})$$

where $\text{Floor}(x)$ represents the largest integer number $= x$

[00231] Hereinafter, it is assumed that the NWA indicates a leading position of the ECC cluster.

- [00232] A track where it is possible to record data is referred to as an open track.
- [00233] The track number of the open track is included in the header information 201 of the session management information 200 shown in Figure 2A (for example, a first open track number 203, a second open track number 204, etc.).
- [00234] Any track other than the open track is referred to as a closed track.
- [00235] For example, a track which does not include any unrecorded area or a track designated by a user can be a closed track.
- [00236] Unlike the open track, the track number of the closed track is not stored in the header information 201 of the session management information 200.
- [00237] The data recording to any closed track is prohibited.
- [00238] In the case where the present invention is applied to the BD-R specification, the term "open track" in the present specification should be read as an "Open SRR" and the term "closed track" should be read as a "Closed SRR".
- [00239] By checking the open track number and the LRA 213 in the track management information 210, it is possible to determine an unrecorded area on the information recording medium 100.
- [00240] By managing the recorded clusters for the write-once type of the information recording medium 100, it is possible to perform a kind of random recording (i.e. recording data at an arbitrary location (physical address) on the information recording medium 100).
- [00241] In order to realize such a random recording, it is necessary to manage unrecorded areas on the information recording medium 100 and to manage the last recorded address.
- [00242] In the present embodiment, these managements are realized by utilizing the space bitmap management information 220 shown in Figure 2C and the disc

management information recorded in the disc management information area 104 and 105.

[00243] When the random recording is performed, the space bitmap management information 220 shown in Figure 2C is recorded in the disc management information area 104.

[00244] Figure 2C shows a data structure of space bitmap management information 220. The space bitmap management information 220 includes header information 221, managed area information 222 and space bitmap information 223.

[00245] The header information 221 includes general information such as an identifier of the space bitmap management information 220.

[00246] The managed area information 222 includes information which specifies an area in the user data area 108, wherein the recorded/unrecorded status of a sector included in the area is managed by the space bitmap management information 220. For example, the managed area information 222 includes a start location of the area and a length of the area.

[00247] The space bitmap information 223 includes information indicating whether each ECC cluster included in the area to be managed is a recorded ECC cluster or an unrecorded ECC cluster. For example, a single bit data is assigned to each ECC cluster, a predetermined value (e.g. "0") is set to the single bit data when the ECC cluster is an unrecorded ECC cluster, and a predetermined value (e.g. "1") is set to the single bit data when the ECC cluster is a recorded ECC cluster. This makes it possible to manage unrecorded areas for all ECC clusters in the area to be managed.

[00248] The disc management information recorded in the disc management information area 104 includes disc structure information 1100 shown in Figure 3.

The disc structure information 1100 includes last recorded address information 1107. The last recorded address information 1107 includes a physical address indicating a location at which data has been lastly recorded within the user data area 108.

[00249] The disc structure information 1100 further includes general information 1101 concerning an entire disc structure information 1100, replacement management information list location information 1102 which indicates location information of the latest replacement management information list 1000 within the disc management information area 104, 105, user area start location information 1103 which indicates a start location of the user data area 108, user area end location information 1104 which indicates an end location of the user data area 108, disc management information area size 1107b, and spare area information 1105 and spare area management information 1108 which indicates the size of the inner spare area 106 and the outer spare area 107 and an area available for replacement.

[00250] By using the disc management information area size 1107b, it is possible to change the size of the disc management information area for each information recording medium. Further, by using the disc management information area size 1107b, it is possible to change the temporal disc management information area described above in the inner spare area 106 and the outer spare area 107.

[00251] By using the spare area information 1105, it is possible to change the size of the spare area for each information recording medium. For example, it is possible to set the size of the inner spare area 106 or the size of the outer spare area 107 to zero.

[00252] The spare area management information 1108 includes next available location information indicating a next available location in the inner spare area 106 and the outer spare area 107.

[00253] In each spare area, a sequential recording is performed in the same way in each track. The next available location in each spare area performs the similar function as the NWA in each track. The recording of new data to each spare area is performed sequentially from the location indicated by the next available location information.

[00254] The disc structure information 1100 further includes session management information location information 1109 which indicates location information of the latest session management information 200 in the disc management information areas 104 and 105, and space bitmap management information location information 1110 which indicates location information of the latest space bitmap management information 220 in the disc management information areas 104 and 105.

[00255] As described above, by using the session management information 200 or the space bitmap management information 220, it is possible to manage the status of unrecorded physical sectors on the information recording medium 100. Accordingly, it is possible to selectively use one of the session management information 200 and the space bitmap management information 220 for its purposes. Alternatively, it is possible to use both information. The information concerning a method for managing unrecorded areas is included in the recording mode information 1106 of the disc structure information 1100.

[00256] The disc management information area 105 is an extended area which is used to record duplication of the disc management information recorded in the disc management information area 104 or is used to record the information which cannot be recorded in the disc management information area 104 in updating the disc management information. Hereinafter, the detailed description of the disc

management information area 105 will be omitted. This is similar to the temporal disc management information recorded in the spare area.

[00257] In the example shown in Figure 1C, the user data recorded in the user data area 108 is managed by a file system. A space managed by the file system is referred to as a volume space 109.

[00258] A plurality of logical sectors are assigned to the volume space 109. Each logical sector is identified by address information such as a logical sector number (hereinafter, "LSN").

[00259] In the description below, it is assumed that information recorded in the information recording medium 100 as the volume/file structure of the file system (e.g. descriptor, pointer, metadata partition and metadata file) has a data structure defined in the ISO/IEC 13346 standard or the UDF (Universal Disc Format) specification, unless it is explicitly described on the contrary. Of course, it is possible to use a file system other than those described above.

[00260] The information recording medium 100 shown in Figures 1A to 1C is described as an information recording medium having a single recording layer. However, the information recording medium 100 may have two or more recording layers.

[00261] Figure 4 shows a data structure of an information recording medium 100b having two recording layers.

[00262] In Figure 4, L0 denotes a first layer and L1 denotes a second layer. Each of the first and second layers has almost the same structure as the information recording medium 100. Specifically, the lead-in area 101 is located in an inner-most periphery of the first layer and the lead-out area 103a is located in an inner-most periphery of the second layer. Further, the outer area 103b is located in an outer-

most periphery of the first layer and the outer area 103c is located in an outer-most periphery of the second layer. The lead-in area 101, the outer area 103b, the lead-out area 103a and the outer area 103c includes a disc management information area 104, 105, 104a and 105a, respectively.

[00263] Further, as shown in Figure 4, the spare areas 106, 106a, 107 and 107a are provided. As described above, it is possible to change the size of each spare area for each information recording medium. It is also possible to provide an additional temporal disc management information area in each spare area. The user data areas 108 and 108a are logically treated as a single volume space having contiguous logical addresses.

[00264] Thus, it is possible to logically treat an information recording medium having a plurality of recording layers as an information recording medium having a single recording layer. Hereinafter, an information recording medium having a single recording layer is described. It is possible to apply the description of the information recording medium having a single recording layer to an information recording medium having a plurality of recording layers. Therefore, an information recording medium having a plurality of recording layers is referred to only when a special description is required.

[00265] 1-2. Pseudo-overwrite recording

[00266] The replacement information is described with reference to Figures 5A and 5B.

[00267] The replacement information is defined as a replacement management information list (or a defect list) including replacement management information (or a defect list entry). The replacement management information (or the defect list entry) includes original location information indicating a location of a cluster in which a

defect occurs on the information recording medium (i.e. a defective cluster) and replacement location information indicating a location of a replacement cluster which is used instead of the defective cluster.

[00268] The present invention enables recording a replacement cluster in the user data area.

[00269] Further, the present invention realizes a pseudo-overwrite recording on a write-once information recording medium using the replacement information.

[00270] As shown in Figure 1B, the data area 102 includes the inner spare area 106, the user data area 108 and the outer spare area 107.

[00271] At least a part of the inner spare area 106 and the outer spare area 107 is used as an area for replacement recording of the data to be recorded in the user data area 108.

[00272] For example, when there exists a defective cluster in the user data area 108, at least a part of the inner spare area 106 and the outer spare area 107 is used as an area for recording a replacement cluster with which the defective cluster is replaced.

[00273] Alternatively, at least a part of the inner spare area 106 and the outer spare area 107 can be used as an area for recording the updated data in the pseudo-overwrite recording described below.

[00274] The replacement recording, which is the combination of the replacement information with the spare area, is performed as well as a verify process.

[00275] The verify process is a process including the steps of reproducing data immediately after the data is recorded, comparing the reproduced data with the recorded data and determining whether or not the data is recorded correctly based

on the comparison result. Such a process including these steps is called a verify-after-write process.

[00276] When an error occurs during the verify process (i.e. it is determined that the data is not recorded correctly), a replacement recording is performed. Specifically, the defective cluster is replaced by a replacement cluster and the data is recorded in the replacement cluster.

[00277] The replacement cluster is recorded in the inner spare area 106 (or the outer spare area 107) or the user data area 108.

[00278] The pseudo-overwrite recording is defined as a method for mapping a physical address at which the data is actually recorded to another physical address, such that it can be seen as if the logical address at which the data is recorded is not changed.

[00279] When the overwrite of new data is instructed to a logical address at which data is recorded, a physical address corresponding to the logical address is replaced by a separate physical address and the new data is written into an ECC cluster on the separate physical address. Then, the ECC cluster before overwrite is mapped to the ECC cluster (replacement cluster) in which the new data is recorded.

[00280] The replacement cluster used in the pseudo-overwrite recording is recorded in the spare area or the user data area.

[00281] As the replacement information for performing such a mapping process, the replacement management information list 1000 shown in Figure 5A is used.

[00282] By performing such a mapping process, it is possible to realize that it can be seen as if the data is overwritten, although the data is not actually overwritten. Hereinafter, this recording method is referred to as a pseudo-overwrite recording.

[00283] Figure 5A shows a data structure of a replacement management information list 1000 which is replacement information according to the present invention. The replacement management information list 1000 is used to map the location of the defective cluster to the location of the replacement cluster. The replacement management information list 1000 includes header information 1001 and a plurality of replacement management information 1010 (e.g. replacement management information #1, #2, #3 ...).

[00284] The header information 1001 includes the number of the replacement management information included in the replacement management information list 1000. The replacement management information includes information indicating the mapping described above.

[00285] Figure 5B shows a data structure of the replacement management information 1010. The replacement management information 1010 includes status information 1011, original location information 1012 and replacement location information 1013.

[00286] The status information 1011 includes status information concerning the mapping described above. For example, the status information indicates a type or an attribute of the replacement management information 1010, the valid/invalid status of the original location information 1012 and the replacement location information 1013 and like.

[00287] The original location information 1012 indicates a location of original information (e.g. a defective cluster).

[00288] The replacement location information 1013 indicates a location of replacement information (e.g. a replacement cluster).

[00289] In the pseudo-overwrite recording, the location of the ECC cluster before overwrite is indicated by the original location information 1012, and the location of the ECC cluster after overwrite is indicated by the replacement location information 1013. Thus, the location of the ECC cluster before overwrite is mapped to the location of the ECC cluster after overwrite.

[00290] Herein, the original location 1012 and the replacement location information 1013 registered in the replacement management information 1010 may be represented by a physical address (e.g. PSN) of the first sector in the corresponding ECC cluster. This is because a mapping is performed as a unit of ECC cluster in the defective management and the pseudo-overwrite recording.

[00291] In the conventional linear replacement method, the replacement cluster is recorded in the spare area. Accordingly, in every case, the information indicating a location of the ECC cluster in the spare area is set to the replacement location information 1013.

[00292] On the other hand, in the present invention, the location at which the replacement cluster can be recorded is not limited to the location in the spare area. It is possible to record the replacement cluster in the user data area. Accordingly, the information indicating a location of the ECC cluster in the spare area or the information indicating a location of the ECC cluster in the user data area may be set to the replacement location information 1013.

[00293] Thus, the replacement location information 1013 may indicate a location of the ECC cluster recorded in one of two areas (i.e. the spare area and the user data area). In order to determine whether the replacement location information 1013 indicates a location of the ECC cluster in the spare area or a location of the ECC

cluster in the user data area, information indicating one of the two cases may be defined. Such information may be incorporated into the status information 1011.

[00294] 1-3. Recording/reproduction apparatus

[00295] Figure 6 shows a configuration of an information recording/reproduction apparatus 300 according to an embodiment of the present invention.

[00296] The information recording/reproduction apparatus 300 includes a host apparatus 305 and a drive apparatus 310.

[00297] The host apparatus 305 can be, for example, a computer system or a personal computer.

[00298] The drive apparatus 310 can be, for example, any one of a recording apparatus, a reproduction apparatus and a recording/reproduction apparatus. The information recording/reproduction apparatus 300 as a whole also can be called any one of a recording apparatus, a reproduction apparatus and a recording/reproduction apparatus.

[00299] The host apparatus 305 includes a system control section 301 and a memory circuit 302. The host apparatus 305 may further include magnetic disc apparatus 304 such as a hard disc drive. The components in the host apparatus 305 are connected to each other via an I/O bus 303.

[00300] The system control section 301 can be implemented, for example, by a microprocessor including a system control program and a memory for operation. The system control section 301 controls various processes and performs various operations such as recording/reproduction of a volume structure/file structure of a file system, recording/reproduction of a metadata partition/file structure described below, recording/reproduction of files and recording/reproduction of the lead-in/lead-out areas.

- [00301] The memory circuit 302 is used to operate information such as a volume structure, a file structure, a metadata partition/file structure and files, and is used to temporarily store them.
- [00302] The drive apparatus 310 includes a drive control section 311, a memory circuit 312, and a recording/reproduction section 314. The components in the drive apparatus 310 are connected to each other via an internal bus 313.
- [00303] The drive control section 310 can be implemented, for example, by a microprocessor including a drive control program and a memory for operation. The drive control section 310 controls various processes and performs various operations such as recording/reproduction of the disc management information area and the spare area and the pseudo-overwrite recording/reproduction.
- [00304] The system control section 301 and drive control section 310 shown in Figure 6 can be implemented by a semiconductor integrated circuit such as an LSI. Alternatively, they can be implemented by a general processor and a memory (e.g. a ROM).
- [00305] A program is stored in the memory (e.g. a ROM). The program is executable by a computer (e.g. a general processor). This program may represent a reproduction process and/or a recording process according to the present invention described above or described below. A computer (e.g. a general processor) performs the reproduction process and/or the recording process according to the present invention in accordance with the program.
- [00306] The memory circuit 312 is used to operate data concerning the disc management information area and the spare area and data transferred to the drive apparatus 310, and is used to temporarily store them.
- [00307] 1-4. Procedure of recording process (1)

- [00308] With reference to Figure 7, the data structure of the information recording medium 100 after performing a format process according to the present embodiment of the invention will be described below.
- [00309] Track #1 401, track #2 402 and track #3 403 are allocated in the user data area 108.
- [00310] A volume space 109 is allocated in the user data area 108. A volume structure area 410, a physical partition 420 and a volume structure area 411 are allocated in the volume space 109.
- [00311] In the physical partition 420, a metadata partition 430 is included. The metadata partition 430 is defined in a pseudo-overwrite method in version 2.5 or higher version of the UDF specification.
- [00312] In the metadata partition 430, a metadata file 440 is recorded. In order to simplify the description, the description of a metadata mirror file is omitted below. The metadata mirror file is a duplication of metadata file 440. The metadata mirror file can be also recorded.
- [00313] A FE (Metadata file) 441 is recorded. The FE (Metadata file) 441 is a file entry (FE) indicating a recording location of the metadata file 440 in the physical partition 420.
- [00314] The information on the file structure such as a file entry (FE) indicating a recording location of a user data file or a directory, is located in the metadata partition 430 (i.e. the metadata file 440).
- [00315] In Figure 7, only the ROOT directory is recorded. In the metadata file 440, only a file set descriptor 433 FE and an FE (ROOT) 442 are recorded. In order to simplify the description, it is assumed that a directory file is included in each FE.

[00316] It is assumed that the state shown in Figure 7 is a state in which any replacement recording has not been performed yet. The management of unrecorded areas in the metadata partition 430 may be performed using a metadata bitmap (not shown) as defined in version 2.5 of the UDF specification.

[00317] Alternatively, it is possible to perform the management of unrecorded areas in the metadata partition 430 by the LRA 405 in the track #1 while maintaining unrecorded areas in the metadata partition 430 unrecorded.

[00318] The method for allocating tracks is not limited to the method shown in Figure 7. For example, more tracks can be allocated. It is possible to add a new track when it is required, while maintaining the state of the last track in the user data area such that the new track can be added to the last track.

[00319] Next, with reference to a flowchart shown in Figure 8A, the procedure of the data recording process will be described below.

[00320] Herein, a case where a data file (File-a) is to be recorded in the information recording medium 100 is described as an example.

[00321] A plurality of physical addresses are assigned to the data area 102 of the information recording medium 100. A plurality of logical addresses are assigned to the user data area 108 of the information recording medium 100. It is assumed that a corresponding relationship between the plurality of logical addresses and the plurality of physical addresses is predetermined.

[00322] Each of the plurality of logical addresses is represented by a logical sector number (LSN) or a logical block address (LBA). Each of the plurality of physical addresses is represented by a physical sector number (PSN) or physical block address (PBA). Further, it is assumed that at least one track is allocated in user data area 108.

- [00323] (Step S101) Prior to recording the data file (File-a), the drive control section 311 performs a preparation process for the data recording. Such a preparation process for the data recording is performed, for example, when the information recording medium 100 is loaded into the drive apparatus 310.
- [00324] For example, the drive control section 311 reads the latest disc management information from the disc management information area 104 (or the disc management information area 105) of the information recording medium 100.
- [00325] The drive control section 311 obtains the user area start location information 1103, the user area end location information 1104, the spare area information 1105 and like from the disc management information in order to determine a primary logical address-physical address mapping indicating the corresponding relationship between the plurality of logical addresses and the plurality of physical addresses assigned to the user data area 108.
- [00326] Hereinafter, the drive control section 311 performs translation between the logical address and primary physical address in accordance with the primary logical address-physical address mapping.
- [00327] The drive control section 311 obtains track management information included in the disc management information area 104.
- [00328] (Step S102) The drive control section 311 receives a recording instruction from the host apparatus 305. The recording instruction includes a logical address indicating a location at which data is to be recorded. This logical address is represented, for example, by a logical sector number (LSN) or a logical block address (LBA). The recording instruction may include a single logical address indicating a location at which single data is to be recorded, or it may include a

plurality of logical addresses indicating a plurality of locations at which a plurality of data are to be recorded respectively.

[00329] The logical address included in the recording instruction is determined, for example, by the host apparatus 305 based on a logical address indicating a location at which data is to be recorded the next time (i.e. a logical next writable address (a logical NWA)).

[00330] The logical NWA is output from the drive apparatus 310 to the host apparatus 305 in response to a request from the host apparatus 305 to the drive apparatus 310, for example.

[00331] The logical NWA is obtained by translating the NWA determined by Expression (1) described above in accordance with the primary logical address-physical address mapping. This translation is performed by the drive control section 311. The procedure for determining the NWA and the logical NWA will be described later in detail in embodiment 2 of the invention.

[00332] The system control section 301 of the host apparatus 305 generates and updates file system information as necessary in order to record data file (File-a). For example, the system control section 301 generates an FE (File-a) for the data file (File-a) and updates the ROOT directory which is a parent directory of the data file (File-a) using the memory circuit 302.

[00333] The generated FE (File-a) for the data file (File-a) and the updated ROOT directory are recorded in the information recording medium 100 by outputting the recording instruction from the host apparatus 305 to the drive apparatus 310. Thus, the latest file system information is reflected on the information recording medium 100.

- [00334] If necessary, the host apparatus 305 inquires the drive apparatus 310 using a predetermined command as to whether or not there is any remaining unrecorded area for performing a replacement recording.
- [00335] The instructions from the host apparatus 305 to the drive apparatus 310 may be a standardized command such as a SCSI multi-media command.
- [00336] For example, a request for the logical NWA may be a READ TRACK INFORMATION command, and a recording instruction may be a WRITE command.
- [00337] (Step S103) The drive control section 311 translates the logical address included in the recording instruction received in step S102 into a physical address in accordance with the primary logical address-physical address mapping.
- [00338] (Step S104) The drive control section 311 determines a track (an open track) of the at least one track allocated in the user data area 108 based on the physical address corresponding to the logical address included in the recording instruction and the track management information 210 (Figure 2B) included in the disc management information.
- [00339] The drive control section 311 determines a physical address indicating a location at which data is to be recorded the next time (i.e. NWA) within the determined track, based on LRA 213 within the determined track. This NWA is a next writable address determined in accordance with Expression (1) described above.
- [00340] The NWA may be determined in step S104. Alternatively, the NWA may be determined in other steps other than step S104 (e.g. in the preparation process for the data recording described above).

[00341] By calculating the NWA using the LRA, it is not necessary to hold the information on the NWA in the track management information. As a result, it is possible to simplify the data structure of the track management information.

[00342] (Step S105) The drive control section 311 determines whether or not the physical address corresponding to the logical address included in the recording instruction is less than the NWA.

[00343] When it is determined that the physical address corresponding to the logical address included in the recording instruction is less than the NWA, the recording instruction is determined as a recording instruction for the recorded area in the user data area 108. In this case, the process proceeds to step S106. Otherwise, the process proceeds to step S108.

[00344] (Step S106) The drive control section 311 determines data to be recorded. When the data recording is performed as a unit of ECC cluster in the information recording medium 100, the drive control section 311 determines the data specified by the recording instruction as the data to be recorded. For example, if the recording location and the size of the data specified by the recording instruction match a boundary of the ECC clusters, then an entire ECC cluster is rewritten. In this case, the drive control section 311 determines the data itself specified by the recording instruction as the data to be recorded.

[00345] If it does not match any boundary of the ECC clusters, then the drive control section 311 performs a read-modify-write process described below. In this case, the drive control section 311 determines the data as a unit of ECC cluster which is obtained during the read-modify-write process as the data to be recorded.

[00346] (Step S107) The drive control section 311 determines the recording location of the data determined in step S106. Specifically, the drive control section 311

determines a specific location in the user data area 108, which is other than the location indicated by the physical address corresponding to the logical address included in the recording instruction, as the recording location of the data determined in step S106.

[00347] The specific location may be the NWA within the track determined in step S104.

[00348] Alternatively, the specific location may be a location indicated by an NWA within an open track which is different from the track determined in step S104. In this case, it is preferable that the NWA within the open track is an NWA which indicates a location which is closest to the location indicated by the physical address corresponding to the logical address included in the recording instruction.

[00349] (Step S108) The drive control section 311 determines whether or not the physical address corresponding to the logical address included in the recording instruction is equal to the NWA.

[00350] When it is determined that the physical address corresponding to the logical address included in the recording instruction is equal to the NWA, the recording instruction is determined as a recording instruction to the location indicated by the NWA. That is, the data recording instructed by the recording instruction is determined as an appending recording (a new recording). In this case, the process proceeds to step S109. Otherwise, the process proceeds to step S111.

[00351] (Step S109) The drive control section 311 determines data to be recorded. Specifically, the drive control section 311 determines the data specified by the recording instruction as the data to be recorded.

[00352] Then, the drive control section 311 determines whether or not the end of the data specified by the recording instruction matches a boundary of the ECC clusters.

If it does not match the boundary of the ECC clusters, padding data (e.g. data consisting of one or more "00" h) is inserted such that the end of the data after insertion matches the boundary of the ECC clusters. In this case, the drive control section 311 determines the data after insertion as the data to be recorded.

[00353] (Step S110) The drive control section 311 determines the recording location of the data determined in step S106. Specifically, the drive control section 311 determines the location indicated by the physical address corresponding to the logical address included in the recording instruction (i.e. the location indicated by the NWA), as the recording location of the data determined in step S106.

[00354] (Step S111) The drive control section 311 performs an error process.

[00355] (Step S112) The drive control section 311 performs a recording process for the determined recording location.

[00356] When the determination result in step S105 is "Yes", the drive control section 311 controls the recording/reproduction section 314 to record the data determined in step S106 at the recording location determined in step S107.

[00357] When the determination result in step S108 is "Yes", the drive control section 311 controls the recording/reproduction section 314 to record the data determined in step S109 at the recording location determined in step S110.

[00358] Further, the drive control section 311 performs a verify process for the recorded data to determine whether or not the data recording has succeeded. If the data recording has succeeded, then the process proceeds to step S113.

[00359] If the data recording has failed, then an unrecorded area in the spare area (e.g. the inner spare area 106) or the user data area 108 is allocated as a replacement cluster, and the data is recorded in the replacement cluster.

[00360] After the data recording has finally succeeded, the process proceeds to step S113.

[00361] For example, the processes of step S106 and step S112 described above is performed as a read-modify-write process (hereinafter RMW process).

[00362] According to the RMW process, firstly, the drive control section 311 controls the recording/reproduction section 314 to reproduce the data recorded in the ECC cluster including a physical sector at a location indicated by the physical address corresponding to the logical address included in the recording instruction, and it stores the data reproduced from the ECC cluster in the memory circuit 312 (i.e. "read" process).

[00363] There is a possibility that the ECC cluster to be reproduced is replaced with a replacement cluster at the time when the reproduction process is performed. The drive control section 311 refers to the replacement management information list 1000, and, if necessary, it controls the recording/reproduction section 314 to reproduce the data recorded in the replacement cluster. The procedure of the data reproduction referring to the replacement management information list 1000 will be described later.

[00364] Secondly, the drive control section 311 replaces the data recorded in the physical sector at the location indicated by the physical address corresponding to the logical address included in the recording instruction among the data reproduced from the ECC cluster with the data included in the recording instruction (i.e. "modify" process). As a result, the data to be recorded in the replacement cluster is obtained.

[00365] The drive control section 311 performs a read process and a modify process in step S106.

[00366] Figure 8B shows the steps performed when the read process and the modify process are performed in step S106 shown in Figure 8A. Each step shown in Figure 8B is performed by the drive control section 311 of the drive apparatus 310.

[00367] (Step S151) The drive control section 311 determines whether or not the ECC cluster including the location specified by the recording instruction has been already replaced by an replacement cluster. Such a determination is made, for example, by retrieving the replacement management information list 1000.

[00368] If the replacement management information 1010 which indicates the location specified by the recording instruction as original location is found, it is determined that the ECC cluster has been already replaced by the replacement cluster and the process proceeds to step S152A. Otherwise, the process proceeds to step S152B.

[00369] By holding the determination result of step S151 as a value of the internal variable, it is possible to refer to the value of the internal variable. By referring to the value of the internal variable, if necessary, in the steps other than step S151, it is possible to determine whether or not the ECC cluster including the location specified by the recording instruction has been already replaced by a replacement cluster. This makes it possible to avoid repeatedly performing the same process. For example, if the determination result of step S151 is "Yes", then the value of "1" may held as the value of the internal variable, and if the determination result of step S151 is "No", then the value of "0" may held as the value of the internal variable.

[00370] (Step S152A) The drive control section 311 determines whether or not the RMW process is required. For example, if the location and the size specified by the recording instruction matches a boundary of the ECC clusters, then drive control section 311 determines that the RMW process is not required. If the location and the size specified by the recording instruction do not match any boundary of the

ECC clusters, then drive control section 311 determines that the RMW process is required.

[00371] If it is determined that the RMW process is required, then the process proceeds to step S153. Otherwise, the process proceeds to step S157.

[00372] Similar to step S151, by holding the determination result of step S152A as a value of the internal variable, it is possible to refer to the value of the internal variable. By referring to the value of the internal variable, if necessary, in the steps other than step S152A, it is possible to determine whether or not the RMW process is required.

[00373] (Step S152B) The drive control section 311 determines whether or not the RMW process is required. The process of step S152B is the same as the process of step S152A.

[00374] (Step S153) The drive control section 311 controls the recording/reproduction section 314 to reproduce the data recorded in the replacement cluster indicated by the replacement management information 1010 found in step S151, instead of the ECC cluster including the location specified by the recording instruction, and stores the reproduced data in the memory circuit 312.

[00375] (Step S154) The drive control section 311 controls the recording/reproduction section 314 to reproduce the data recorded in the ECC cluster including the location specified by the recording instruction, and stores the reproduced data in the memory circuit 312.

[00376] (Step S155) The drive control section 311 replaces the reproduced data by the data specified by the recording instruction so as to generate a modified data.

[00377] (Step S156) The drive control section 311 determines the modified data as the data to be recorded in the information recording medium 100.

[00378] (Step S157) The drive control section 311 determines the data specified by the recording instruction as the data to be recorded in the information recording medium 100.

[00379] Thus, the read process and the modify process are completed.

[00380] Thirdly, the drive control section 311 controls the recording/reproduction section 314 to record the data obtained as a result of the modify process (i.e. the data to be recorded in the replacement cluster) in a location of the original ECC cluster (i.e. "write" process). The drive control section 311 performs write process in step S112.

[00381] However, in the present invention, since the information recording medium is a write-once recording medium, it is not possible to actually record the data in a location of the original ECC cluster.

[00382] Accordingly, in the present invention, an unrecorded area in the spare area such as the inner spare area 106 or the user data area 108 is allocated as a replacement cluster, and the updated data is recorded in the replacement cluster.

[00383] Further, the drive control section 311 performs a verify process to determine whether or not the data recording has succeeded. When it is determined that the data recording has succeeded, the process proceeds to step S113.

[00384] When it is determined that the data recording has failed, an unrecorded area in the spare area such as the inner spare area 106 or the user data area 108 is allocated as a further replacement cluster, and the data is recorded in the further replacement cluster.

[00385] After the data recording has finally succeeded, the process proceeds to step S113.

[00386] When the area specified by the recording instruction corresponds to an entire ECC cluster, the entire ECC block is rewritten. In this case, the read process described above is not required.

[00387] (Step S113) The drive control section 311 generates replacement management information 1010 in accordance with the process in step 5112, and stores the replacement management information 1010 in memory circuit 312. For example, in step S112, when the drive control section 311 controls the recording/reproduction section 314 to record data at a specific location in the user data area 108 wherein the specific location is any location other than the location indicated by the physical address corresponding to the logical address included in the recording instruction, the drive control section 311 generates replacement management information 1010 which maps the physical address corresponding to the logical address included in the recording instruction to a physical address indicating the specific location.

[00388] It is possible to determine whether or not the replacement management information 1010 having the original location information 1012, which indicates the same location as the physical address corresponding to the logical address included in the recording instruction, is found in the existing replacement management information list 1000 by retrieving the existing replacement management information list 1000.

[00389] If it is found, the drive control section 311 updates the replacement management information 1010 so as to set the physical address indication of the specific address as a new replacement location information 1013.

[00390] If it is not found, the drive control section 311 generates new replacement management information 1010 and adds the new replacement management information 1010 to the replacement management information list 1000.

[00391] Next, the drive control section 311 sorts the replacement management information list 1000. For example, the drive control section 311 sorts the replacement management information list 1000 by the status information 1011, and then sorts it by the physical address indicated by the original location information 1012.

[00392] Thus, a new replacement management information list 1000 including the replacement management information 1010 which maps the physical address corresponding to the logical address included in the recording instruction to the physical address indicating the specific location is generated.

[00393] (Step S114) The drive control section 311 updates the disc management information to reflect the recording process described above. For example, the drive control section 311 updates the last recorded address information 1107. In addition, the drive control section 311 updates the LRA 213 in each track management information 210 corresponding to the tracks in which data have been recorded to reflect the latest recording status.

[00394] Further, the drive control section 311 generates the new disc management information including the updated information such as the new replacement management information list 1000 and track management information 210. In addition, the drive control section 311 sets the replacement management information list location information 1102 and the session management information location information 1109 included in the new disc management information to indicate the latest recording location of the new replacement management

information list 1000 and track management information 210 on the information recording medium 100.

[00395] The drive control section 311 controls the recording/reproduction section 314 to record the new disc management information in a predetermined area (e.g. a temporal disc management information area) on the information recording medium 100. Thus, the disc management information is updated to reflect the latest status.

[00396] When the data recording is completed, the drive apparatus 310 can notify the host apparatus 305 of the result of the recording process. The result of the recording process is, for example, information indicating that the data recording has succeeded or failed.

[00397] Such a notification can be sent to the host apparatus 305 at a predetermined timing. For example, it is possible to send this notification to the host apparatus 305 at the timing of the end of step S108 or at the timing when an error occurs in step S112. Alternatively, it is possible to send this notification before the data recording is actually completed. For example, it is possible to send a notification indicating that the data recording is completed to the host apparatus 305 at the timing when the interpretation of the received record instruction is completed correctly.

[00398] In the replacement recording process, it is possible to retrieve an unrecorded area in a direction along which the PSNs are increased from the location of the original ECC cluster. If the unrecorded area is found during the retrieval, the unrecorded area is allocated as a replacement cluster.

[00399] Alternatively, it is possible to first retrieve an unrecorded area in a track including the original ECC cluster, and then retrieve an unrecorded area for each track in a direction along which the PSNs are increased from the track.

[00400] When the retrieval for the unrecorded area reaches the end of the user data area 108 without finding any unrecorded area, it is possible to retrieve an unrecorded area in the outer spare area 107 following the user data area 108.

[00401] Further, the retrieval for the unrecorded area reaches the end of the outer spare area 107 without finding any unrecorded area, it is possible to retrieve an unrecorded area in a direction along which the PSNs are increased from a predetermined location at the inner side of the information recording medium 100 (e.g. a leading position of the inner spare area 106 or a leading position of the user data area 108 or a location apart from its leading position by a predetermined distance).

[00402] In steps S105 and S108 of the procedure of the recording process, it is determined whether the data recording is a pseudo-overwrite recording or an appending recording by comparing the physical address corresponding to the logical address included in the recording instruction with the NWA.

[00403] The reason why it is determined whether the data recording is a pseudo-overwrite recording or an appending recording based on such a comparison is that the information recording medium 100 is a write-once recording medium and that a sequential recording is performed for the write-once recording medium.

[00404] The replacement recording method using the user data area described above according to the present invention is applicable to any rewritable optical disc. However, in order to determine whether the data recording is a overwrite recording or an appending recording (or a new recording) for the rewritable optical disc, a more complex process is required. This is because, in the case of the rewritable optical disc, it is possible to randomly rewrite data at an arbitrary location on the optical disc.

[00405] When the drive apparatus manages an unrecorded area on the rewritable optical disc as described in the embodiment above, it is necessary to manage replacement management information corresponding to all ECC clusters on the rewritable optical disc using the SDL, as described in the background art of the present specification, for example. Further, in order to determine whether the data recording for recording data at a certain location in the user data area is an overwrite recording or a new recording, it is necessary to retrieve an entire replacement management information list 1000, for example. Similarly, in order to determine whether or not an ECC cluster is used as a replacement cluster, it is necessary to retrieve an entire replacement management information list 1000. The amount of such a retrieving process is increased as the size of the replacement management information list 1000 is increased. This should be a problem since the capacity of the optical disc is being increased more and more.

[00406] On the other hand, in the present invention, since the information recording medium 100 is a write-once recording medium, it is ensured that every area in a track which has an address less than the NWA is an unrecorded area.

[00407] Accordingly, by performing the comparison described in steps S105 and S108, it is possible to easily determine whether the data recording is a pseudo-overwrite recording or an appending recording, regardless of the size of the replacement management information list 1000. Further, it is possible to easily select a replacement cluster since the replacement cluster can be selected from any location after the NWA.

[00408] The pseudo-overwrite recording in a random recording method for a write-once optical disc is performed in a similar way as the rewritable optical disc.

[00409] Further, in order to perform the random recording method for the write-once optical disc, a special structure such as the space bitmap management information 220 is required. The management of the unrecorded area for the random recording method using the space bitmap management information 220 requires significantly greater processing load to the drive control section 311, compared to the management of the unrecorded area for the sequential recording method.

[00410] In particular, in the sequential recording method, it is possible to limit the number of open tracks to a predetermined number (for example, four at maximum) so that the utilization of a file system is not reduced.

[00411] In this case, the number of open tracks depends on the structure of the file system, and it is independent from the capacity of the optical disc. On the other hand, the size of the space bitmap management information 220 is increased as the capacity of the optical disc is increased. As a result, the processing load is also increased.

[00412] Thus, the effect of the present invention for performing a pseudo-overwrite in the sequential recording method is very significant for the optical disc, since the capacity of the optical disc is being increased more and more.

[00413] One feature of the present invention is to determine an NWA in accordance with LRA 213 included in the latest track management information 210 and expression (1) in order to determine whether the data recording is a pseudo-overwrite recording or an appending recording.

[00414] By recording the LRA 213, which has been updated as a result of the data recording, on the disc, it is possible to reduce the time required to find the latest LRA 213 when the information recording medium 100 is loaded into the drive apparatus 310.

[00415] By calculating the NWA using the LRA 213, it is not necessary to hold information on the NWA in the track information. As a result, it is possible to simplify the data structure of the track management information.

[00416] In order to determine whether the data recording is a pseudo-overwrite recording or an appending recording without using a method according to the present invention, the following procedure is required, for example.

[00417] Specifically, the procedure includes the steps of determining a track including a physical address corresponding to the logical address included in the recording instruction, sequentially checking ECC clusters from a leading position of the determined track, and determining whether or not each of the ECC clusters is recorded.

[00418] If the ECC cluster is in a recorded state at a location indicated by the recording instruction, then it is determined that the data recording is a pseudo-overwrite recording.

[00419] However, it is not preferable to perform such a procedure since the amount of the required processing is increased as the size of the track is increased.

[00420] On the other hand, according to the present invention, it is possible to easily determine whether the data recording is a pseudo-overwrite recording or an appending recording, regardless of the size of the track.

[00421] Further, since LRA 213 is included in the track management information 210, it is possible to easily determine an NWA as well as the determination of a track in which the data is to be recorded when the drive apparatus 310 receives the recording instruction.

- [00422] Figure 9 shows a data structure on the information recording medium 100 after the data file has been recorded in accordance with the procedure of the data recording.
- [00423] Referring to Figure 9, data file (File-a) 460 is described as an example of the data file. It is assumed that a defective cluster #1 and a defective cluster #2 are detected in the data file (File-a) 460 in the procedure of the data recording.
- [00424] The disc management information including replacement management information indicating a replacement of the defective cluster #1 with a replacement cluster #1 and a replacement management information indicating a replacement of the defective cluster #2 with a replacement cluster #2 is recorded in the disc management information area 104.
- [00425] As shown in Figure 9, the replacement cluster #1 is recorded in the inner spare area 106 and the replacement cluster #2 is recorded in the user data area 108.
- [00426] The content of the data file (File-a) 460 is updated by the pseudo-overwrite recording. Specifically, an overwritten cluster #3 and an overwritten cluster #4 correspond to the updated portions of the data file (File-a) 460 according to the pseudo-overwrite recording.
- [00427] The new data updated by the pseudo-overwrite recording is recorded in a replacement cluster #3 assigned as the substitute for the overwritten cluster #3 and is recorded in a replacement cluster #4 assigned as the substitute for the overwritten cluster #4. The corresponding replacement information is recorded in the disc management information area 104.

[00428] As shown in Figure 9, the replacement cluster #3 is assigned in the inner spare area 106 and the replacement cluster #4 is assigned in the user data area 108.

[00429] 1-5. Procedure of reproduction process (1)

[00430] With reference to a flowchart shown in Figure 10, a reproduction process for a file is described. Herein, a reproduction process for the data file (File-a) 460 shown in Figure 9 is described as an example.

[00431] (Step S201) Prior to performing a reproduction process, the drive control section 311 performs a preparation process for the data reproduction. Such a preparation process for the data reproduction is performed, for example, when the information recording medium 100 is loaded into the drive apparatus 310.

[00432] For example, the drive control section 311 reads disc management information from the disc management information area 104 (or the disc management information area 105) of the information recording medium 100.

[00433] The drive control section 311 obtains user area start location information 1103, user area end location information 1104, spare area information 1105 and like from the disc management information to generate a primary logical address-physical address mapping indicating the corresponding relationship between the plurality of logical addresses and the plurality of physical addresses assigned to the user data area 108.

[00434] Hereinafter, the drive apparatus 310 performs translation between the logical address and the primary physical address in accordance with primary logical address-physical address mapping.

[00435] (Step S202) The system control section 301 outputs a reproduction instruction to the drive apparatus 310 to reproduce an AVDP recorded at a predetermined location (e.g. LSN=256) of the information recording medium 100.

[00436] The AVDP is a data structure defined by the UDF specification as an anchor point of the file system information. The AVDP is recorded in the volume structure area 410 and the volume structure area 411.

[00437] (Step S203) The system control section 301 obtains location information of a main volume descriptor sequence 410A recorded in the volume structure area 410 from the AVDP. The system control section 301 outputs an instruction to the drive apparatus 310 to reproduce the main volume structure 410A.

[00438] Further, the system control section 301 obtains location information (LSN) of an FE (metadata file) 441 by retrieving the data structure from the reproduced main volume descriptor sequence 410A in steps.

[00439] (Step S204) The system control section 301 reproduces a file structure. In order to reproduce the file structure, the system control section 301 outputs a reproduction instruction to the drive apparatus 310 based on the obtained location information (LSN) of the FE (metadata file) 441 to reproduce the FE (metadata file) 441.

[00440] The system control section 301 obtains location information of a metadata file 440 from the reproduced FE (metadata file) 441. As a result, it is possible to access the metadata file 440.

[00441] (Step S205) In accordance with the procedure of the data reproduction based on the UDF specification, the FDS 433, the FE (ROOT) 442, the FE (File-a) 443 and the data file (File-a) 460 are reproduced in this order. The description of the reproduction of the directory file is omitted.

[00442] In each step in the reproduction process described above, a reproduction instruction is output from the host apparatus 305 to the drive apparatus 310. The drive control section 311 of the drive apparatus 310 receives the reproduction instruction from the host apparatus 305, and performs a reproduction process in accordance with the reproduction instruction.

[00443] The reproduction instruction includes a logical address indicating a location from which data is to be reproduced. The logical address is, for example, represented by a logical sector number (LSN). Alternatively, the logical address may be represented by a logical block address (LBA). The reproduction instruction is, for example, a READ command.

[00444] The drive control section 311 translates the logical address included in the reproduction instruction into a physical address in accordance with the primary logical address-physical address mapping (for example, see Figure 12).

[00445] The drive control section 311 determines whether or not the replacement management information 1010 having the original location information 1012, which indicates the same location as the physical address corresponding to the logical address included in the reproduction instruction, is found in the replacement management information list 1000 by retrieving the replacement management information list 1000.

[00446] If it is found, the drive control section 311 refers to the replacement location information 1013 of the replacement management information 1010 and controls the recording/reproduction section 314 to reproduce data from the location indicated by the replacement location information 1013.

[00447] If it is not found, the drive control section 311 controls the recording/reproduction section 314 to reproduce data from the location indicated by the

physical address corresponding to the logical address included in the reproduction instruction. The reproduced data is sent back to the host apparatus 305.

[00448] 1-6. Procedure of recording process (2)

[00449] Figure 11 shows a data structure of the replacement management information 1010B. The replacement management information 1010B is a different embodiment of the replacement management information 1010 shown in Figure 5B.

[00450] As shown in Figure 11, the status information 1011 of the replacement management information 1010B includes three information, i.e. Flag1, Flag2 and Flag3.

[00451] Flag1 is information for classifying the replacement management information 1010B. Flag1 includes information indicating whether the replacement information is for the purpose of the replacement recording or for the purpose of the designation of the defective cluster.

[00452] Flag2 is information on the recording location of the replacement cluster managed by the replacement management information 1010B. Flag2 includes information indicating whether the recording location of the replacement cluster is in the spare area (or there is no replacement cluster) or the recording location of the replacement cluster is in the user data area.

[00453] Flag3 is information on the number of the clusters managed by the replacement management information 1010B, Flag3 includes information indicating whether the replacement information corresponds to a single cluster or a plurality of contiguous clusters. When the replacement information corresponds to a plurality of contiguous clusters, Flag3 further includes information indicating whether the replacement information corresponds to a start location of the contiguous range or an end location of the contiguous range.

[00454] Hereinafter, with reference to Figure 11, the procedure of the data recording according to the present invention will be described in detail.

[00455] The symbols at the right side of Figure 11 represent the respective types of the replacement management information. These symbols are referred to in the description below, if necessary. For example, the replacement management information (type (1)) includes the status information 1011 such that Flag1=1 (for the purpose of the replacement recording), Flag2=0 (for the replacement in the spare area) and Flag3=00 (for a single cluster). This replacement management information (type (1)) may be denoted by the replacement management information (1).

[00456] Figure 12 shows an example of the data structure of the physical address space and the logical address space on the information recording medium 100 according to the present invention.

[00457] Figure 12 also shows a corresponding relationship between the logical sector number (LSN) and the physical sector number (PSN) in a primary state. The logical sector number (LSN) is a logical address indicating a location which is seen from the host apparatus 305 on the information recording medium 100. The physical sector number (PSN) is a physical address indicating an actual location on the information recording medium 100. This corresponding relationship is referred to as a primary logical address-physical address mapping. This mapping is represented by broken line arrows in Figure 12 (or other figures).

[00458] Each row shown in Figure 12 corresponds to one ECC cluster. In Figure 12, a physical address (PSN) and a logical address (LSN) corresponding to the physical address (PSN) are shown in the same row.

- [00459] In Figure 12, the values of the PSNs and the LSNs are shown as the values of the PSNs and the LSNs from the first sector to the last sector in the corresponding ECC cluster.
- [00460] Herein, it is assumed that one ECC cluster consists of 32 sectors. However, one ECC cluster may be any other configuration.
- [00461] The PSNs are assigned to the inner spare area 106, the outer spare area 107 and the user data area 108.
- [00462] The tracks are allocated from a leading position of the user data area 108. In the state shown in Figure 12, since no data is recorded, the LRA 500 designates a leading position of the user data area 108.
- [00463] The LSNs are assigned to only the user data area 108 (or the volume space 109).
- [00464] The host apparatus 305 instructs a recording process or a reproduction process. These instructions specify a specific logical sector on the information recording medium 100 using the LSN.
- [00465] The drive apparatus 310 translates the LSN received from the host apparatus 305 into a PSN using the primary logical address-physical address mapping, and accesses a physical sector or ECC cluster in accordance with the PSN.
- [00466] In the replacement recording described hereinafter, the primary logical address-physical address mapping is basically used. When the logical address-physical address mapping other than the primary logical address-physical address mapping is required, the replacement management information 1010 is used.
- [00467] The values of the PSNs and the LSNs are only examples for explanation. These values can be varied depending on the structure and the capacity of the information recording medium 100.

[00468] As described above, the size of the disc management information and the spare area can be changed. The size of these is determined at the time when the format process is performed in response to an instruction from the host apparatus 305. After the format process, the start location and the end location of the user data area 108 is not changed.

[00469] In this case, it is possible to determine a relationship of the primary logical address-physical address mapping uniquely (e.g. by a predetermined calculation) from information of the disc structure information 1100 (e.g. in more detail, user area start location information 1103, user area end location information 1104, spare area information 1105 and like) included in the disc management information.

[00470] With reference to Figures 12 to 17B, an exemplary use of the replacement management information 1010B shown in Figure 11 will be described.

[00471] Firstly, the transition from the state shown in Figure 12 to the state shown in Figure 13A is described.

[00472] The host apparatus 305 instructs to record data "A" at a location of LSN=0.

[00473] Upon the receipt of the recording instruction, the drive apparatus 310 translates LSN=0 into PSN=1100 in accordance with the primary logical address-physical address mapping and records data "A" at a location of PSN=1100.

[00474] Next, the drive apparatus 310 performs a verify process for the recorded data. Herein, it is assumed that the recording of data "A" has succeeded.

[00475] The host apparatus 305 instructs to record data "A1" at a location of LSN=0.

[00476] Upon the receipt of the recording instruction, the drive apparatus 310 translates LSN=0 into PSN=1100 in accordance with the primary logical address-physical address mapping and performs a RMW process at a location of

PSN=1100. Then, the drive apparatus 310 records data "A1" at a location of PSN=100 in the inner spare area 106.

[00477] The drive apparatus 310 generates replacement management information 511. The location of PSN=1100 at which data "A" is recorded is set to the original location of the replacement management information 511. The location of PSN=100 at which data "A1" is recorded is set to the replacement location of the replacement management information 511. The status information 1011 of the replacement management information 511 is set in accordance with Figure 11.

[00478] The replacement management information 511 corresponds to solid line arrows shown in Figure 13A. The tail of each arrow represents the original location of the replacement management information 511 and the head of each arrow represents the replacement location of the replacement management information 511. Hereinafter, a similar notation will be used.

[00479] In the state shown in Figure 13A, the host apparatus 305 instructs to record data "B" at a location of LSN=2. Herein, it is assumed that the recording of data "B" has failed. Then, the data "B" is recorded at a location of PSN=132 in the inner spare area 106.

[00480] The replacement management information 512 is generated in response to this replacement recording. The location of PSN=1032 is set to the original location of the replacement management information 512. The location of PSN=132 is set to the replacement location of the replacement management information 512. The status information 1011 of the replacement management information 512 is set in accordance with Figure 11.

[00481] The data allocation and the replacement management information list after the data recording described above is completed are shown in Figure 13A and

Figure 13B, respectively. In the replacement management information list 1000A shown in Figure 13B, the replacement management information (1) is used.

[00482] With reference to Figures 14A and 14B, the cases where the replacement management information (4) and (7) are used will be described.

[00483] The host apparatus 305 instructs to record data "C" at a location of LSN=64. In accordance with the recording instruction, the drive apparatus 310 records data "C" at a location of PSN=1164. Herein, it is assumed that the recording of data "C" has failed. Then, a recorded area in the user data area 108 (PSN=1196) is allocated and the data "C" is recorded at a location of PSN=1196 instead of the location of PSN=1164.

[00484] The replacement management information 513 is generated in response to this replacement recording.

[00485] The host apparatus 305 instructs to record data "D" at a location of LSN=128. Then, the host apparatus 305 instructs to record data "D1". Herein, it is assumed that the recording of data "D1" has failed. Then, the data "D1" is recorded at a location of PSN=1292.

[00486] The replacement management information 514 is generated in response to this replacement recording.

[00487] PSN=1260 indicates a location of a defective cluster, wherein there is no replacement cluster corresponding to the defective cluster. Then, the replacement management information 515 is generated.

[00488] The host apparatus 305 instructs to record data "D2" at a location of LSN=128. Then, the data "D2" is recorded at a location of PSN=1324.

[00489] The replacement management information 514A is generated in response to this replacement recording. The replacement management information 514

becomes unnecessary. Accordingly, the replacement management information 514 is deleted from the replacement management information list 1000.

[00490] After the recording process described above is completed, the location of the LRA is updated to a location indicated by 500B.

[00491] The replacement management information list 1000B (Figure 14B) is sorted by Flag1 of the status information 1011, and then it is sorted by the value of PSN indicated by the original location information 1012.

[00492] With reference to Figures 15A and 15B, the cases where the replacement management information (5) and (6) are used will be described.

[00493] The host apparatus 305 instructs to record data "E" at a location of LSN=256~X1. Herein, it is assumed that the recording of data "E" has failed. Then, the data "E" is recorded at a location of PSN=x2~x3. The replacement management information 516 and the replacement management information 517 are generated. Each of the replacement management information 516 and 517 indicates the first PSN of the ECC cluster corresponding to a start location of the replacement recording and the first PSN of the ECC cluster corresponding to an end location of the replacement recording.

[00494] In the state shown in Figures 16A and 16B, the host apparatus 305 instructs to record data "E1" at a location of LSN=256~X1. Then, the data "E1" is recorded at a location of PSN=x4~x5, which are an recorded area in the state shown in Figure 15A.

[00495] The replacement management information 516A is generated as information indicating a start point of the replacement recording. The replacement management information 517A is generated as information indicating an end point of the replacement recording.

[00496] At this time, the replacement management information 516 and 517 become unnecessary. Accordingly, the replacement management information 516 and 517 are deleted from the replacement management information list 1000.

[00497] In the examples shown in Figures 15A and 16A, all of data are recorded in the user data area 108 as a result of the replacement recording. However, it is possible to record these data in the inner spare area 106. In this case, the replacement management information (2) and (3) are used.

[00498] As described in reference with Figure 8A, the updated replacement management information list is recorded in the disc management information area.

[00499] 1-7. Procedure of reproduction process (2)

[00500] In order to reproduce the recorded data, the following reproduction process is performed.

[00501] Prior to performing a reproduction process, the drive control section 311 performs a preparation process for the data reproduction. Such a preparation process for the data reproduction is performed, for example, in a manner similar to step S201 described above.

[00502] For example, in the state shown in Figure 13A, the host apparatus 305 outputs a reproduction instruction to the drive apparatus 310 to reproduce data "B" at a location of LSN=32. The drive apparatus 310 translates the location of LSN=32 into a location of PSN=1132 in accordance with the primary logical address-physical address mapping.

[00503] The drive apparatus 310 retrieves the replacement management information having a location of PSN=1132 as an original location in the latest replacement management information list 1000.

- [00504] In this case, the replacement management information 512 is found, the drive apparatus 310 obtains a location of PSN=132 as a replacement location.
- [00505] The drive apparatus 310 reproduces data "B" from the location of PSN=132 and sends the reproduced data back to the host apparatus 305.
- [00506] Even if the LSN specified by the host apparatus 305 is changed, the drive apparatus 310 performs the same reproduction process. Specifically, the drive apparatus 310 translates the received LSN into a PSN in accordance with the primary logical address-physical address mapping, and determines whether or not the replacement management information corresponding to the PSN is found in the replacement management information list 1000. If it is found, then the data is reproduced from the replacement cluster. If it is not found, then the data is reproduced from the PSN.
- [00507] As described above, it is possible to use the user data area 108 as an area for a replacement location without any loss in the pseudo-overwrite recording for the information recording medium 100.
- [00508] 1-8. Procedure of recording process (3)
- [00509] Figure 18 shows a data structure of a DFL entry 2010. The DFL entry 2010 is a different embodiment of the replacement management information 1010 and the replacement management information 1010B described above.
- [00510] The DFL entry 2010 includes status 1 2011A, status 2 2011B, a defective cluster first PSN 2012 and a replacement cluster leading PSN 2013. The status 1 2011A and the status 2 2011B correspond to the status information 1011 described above. The defective cluster first PSN 2012 corresponds to the original location information 1012 described above. The replacement cluster first PSN 2013 corresponds to the replacement location information 1013 described above.

[00511] Herein, similar to the explanation with reference to figure 5B, the defective cluster first PNS 2012 and the replacement cluster first PSN 2013 may be represented by a physical address (e.g. PSN) of the first sector in the corresponding ECC cluster. This is because a mapping is performed as a unit of ECC cluster in the defective management and the pseudo-overwrite recording.

[00512] The status 1 2011A includes at least information corresponding to Flag1 and Flag2 in the replacement management information 1010B. For example, when the status 1 2011A has a value of "1000", it is determined that there is no replacement cluster for the replacement information. This corresponds to a case where Flag2=0 and there is no replacement cluster. In this case, a value of "0" is set to the replacement cluster first PSN 2013.

[00513] On the other hand, when there exists a replacement cluster, a value of "0000" is set to the status 1 2011A. This corresponds to a case where Flag2=0 and there is a replacement cluster.

[00514] The status 2 2011B includes at least information corresponding to Flag3 in the replacement management information 1010B. For example, when the status 2 2011B has a value of "0000", it is determined that the replacement information corresponds to a single cluster. This corresponds to a case where Flag3=00.

[00515] When the status 2 2011B has a value of "0001", it is determined that the replacement information corresponds to a location of the first sector of a start cluster of a contiguous range including a plurality of clusters. This corresponds to a case where Flag3=01. When the status 2 2011B has a value of "0010", it is determined that the replacement information corresponds to a location of the last sector of an end cluster of a contiguous range including a plurality of clusters. This corresponds to a case where Flag3=10.

- [00516] The DFL entry 2010 can be applied to all embodiments.
- [00517] With reference to the data structure of the DFL entry 2010 shown in Figure 18 and the flowchart shown in Figure 19A, an exemplary process for the replacement management information in step S113 of Figure 8A will be described in detail.
- [00518] Herein, it is assumed that the replacement recording for the pseudo-overwrite recording is performed in step S112 shown in Figure 8A and then the process proceeds to step S113.
- [00519] (Step S301) It is determined whether the pseudo-overwrite recording is a first time replacement recording or a second time or more replacement recording.
- [00520] This determination is performed, for example, by retrieving a DFL entry 2010 having a value of the first PSN of the ECC cluster including the physical address corresponding to the logical address included in the recording instruction as a value of the defective cluster first PSN 2012 in the latest replacement management information list. The physical address corresponding to the logical address included in the recording instruction is obtained in step S103 shown in Figure 8A.
- [00521] This latest replacement management information list is reproduced from the disc management information area and is stored in the memory circuit 312 in step S101 (Figure 8A), for example.
- [00522] When the corresponding replacement management information (e.g. the DFL entry 2010) is not found in the replacement management information list, it is determined that the pseudo-overwrite recording is a first time replacement recording. As a result, the process proceeds to step S302.
- [00523] When the corresponding replacement management information is found in the replacement management information list, it is determined that the pseudo-

overwrite recording is a second time or more replacement recording. As a result, the process proceeds to step S304.

[00524] Whether the pseudo-overwrite recording is a first time replacement recording or a second time or more replacement recording may be predetermined in another step. For example, it may be predetermined in step S106. The determination result in step S106 may be held and may be used in step S301.

[00525] (Step S302) The first time replacement recording is performed as follows.

[00526] The drive control section 311 creates a new DFL entry 2010 and stores it in the memory circuit 312.

[00527] (Step S303) The drive control section 311 sets values to the DFL entry 2010.

[00528] An appropriate value is set to the status 1 2011A of the DFL entry 2010. For example, when the replacement recording is performed with the replacement cluster, the value of "0000" is set to the status 1 2011A of the DFL entry 2010.

[00529] A value of a first PSN of the ECC cluster located at the physical address corresponding to the logical address included in the recording instruction is set to the defective cluster first PSN 2012 of the DFL entry 2010.

[00530] A value of a first PSN of the replacement cluster in which the data is actually recorded in the replacement recording is set to the replacement cluster first PSN 2013 of the DFL entry 2010.

[00531] An appropriate value is set to the status 2 2011B of the DFL entry 2010. For example, when the replacement recording is performed for the single cluster, the value of "0000" is set to the status 2 2011B of the DFL entry 2010.

[00532] (Step S304) The second time or more replacement recording is performed as follows.

[00533] The process proceeds to step S305 in order to update the DFL entry 2010 which has been found in step S301.

[00534] (Step S305) The status 1 2011A of the DFL entry 2010 is updated to an appropriate value. For example, when the replacement recording is performed and there exists a replacement cluster, the value of "0000" is set to the status 1 2011A of the DFL entry 2010.

[00535] The replacement cluster first PSN 2013 of the DFL entry 2010 is updated to a value of a first PSN of the replacement cluster in which the data is actually recorded in the replacement recording. That is, the location of a new replacement cluster is set.

[00536] It is not necessary to update the defective cluster first PSN 2012 of the DFL entry 2010, since the second time or more replacement recording is performed for the same ECC cluster. The defective cluster first PSN 2012 of the DFL entry 2010 maintains the same value.

[00537] The status 2 2011B of the DFL entry 2010 is updated to an appropriate value. For example, when the replacement recording is performed for the single cluster, the value of "0000" is set to the status 2 2011B of the DFL entry 2010.

[00538] (Step S306) According to the process mentioned above, the replacement management information list is updated. That is, a new DFL entry 2010 is added to the replacement management information list or the existing DFL entry 2010 in the replacement management information list is updated.

[00539] Then, the replacement management information list is sorted. For example, the replacement management information list is sorted by the status 1 2011A. Further, the replacement management information list is sorted by the defective

cluster first PSN 2012, the status 2 2011B and the replacement cluster first PSN 2013, in this order.

[00540] The process of step S113 shown in Figure 8A is terminated. The latest replacement management information list obtained in the process is additionally recorded in the (temporary) disc management information area.

[00541] In the exemplary process, a case is described where the replacement recording for the pseudo-overwrite recording is performed. However, the process can be also applied to the replacement recording due to the occurrence of the defective cluster.

[00542] As described in the background art with reference to Figures 33A and 33B, in the conventional defective management for the write-once optical discs, new replacement management information is added to the replacement management information list each time the replacement recording is performed, while maintaining the existing replacement management information in the replacement management information list.

[00543] When such a method is applied to a recording method in which the user data area is used as an area for recording a replacement cluster as described in the present embodiment, the number of the replacement management information is increased each time the replacement recording is performed, and the size of the replacement management information list is increased each time the replacement recording is performed. This is not preferable in implementing the drive apparatus and the like.

[00544] In particular, in the conventional defective management for the write-once optical discs, the cluster which has been replaced with another cluster is not further replaced. However, in the pseudo-overwrite recording as described in the present

embodiment, it is possible to further replace the cluster which has been replaced with another cluster. Accordingly, there is a possibility that the size of the replacement management information list is much increased.

[00545] Further, it is possible that there exists a plurality of replacement management information in the replacement management information list, wherein each of the plurality of replacement management information has the same value as the defective cluster first PSN 2012. Accordingly, an additional process and/or structure are required to obtain the latest replacement management information.

[00546] In the defective management for the rewritable optical discs, the replacement management information is provided for every replacement cluster, regardless of whether or not the replacement cluster is actually used.

[00547] When such a method is applied to a recording method in which the user data area is used as an area for recording a replacement cluster as described in the present embodiment, a large amount of replacement management information is required from an initial state. This is not preferable in implementing the drive apparatus and the like.

[00548] According to the method shown in Figure 19A, it is sufficient to generate and manage the minimum number of replacement management information. It is possible to easily find the latest replacement management information.

[00549] 1-9. Procedure of recording process (4)

[00550] With reference to Figure 19B, an exemplary process of the replacement management information in the procedure of the recording process will be described in more detail.

[00551] The respective steps shown in Figure 19B are included in step S113 shown in Figure 8A. The following description refers to a data structure of the DFL entry

2010 which is an example of the replacement management information shown in Figure 18.

[00552] Herein, it is assumed that the replacement recording for the pseudo-overwrite recording is performed in step S112 shown in Figure 8A and then the process proceeds to step S113.

[00553] (Step S601) The drive control section 311 determines whether or not the area specified by the recording instruction is a contiguous range in the physical address space.

[00554] For example, the drive control section 311 determines the size of the area on the physical address space based on the recording location specified by the recording instruction and the size of the data to be recorded specified by the recording instruction. When the size of the area on the physical address space which is thus determined is greater than the size of one ECC cluster, the drive control section 311 determines that the area specified by the recording instruction is a contiguous range in the physical address space.

[00555] If the determination result in step S601 is "Yes", then the process proceeds to step S602. If the determination result in step S601 is "No", then the process proceeds to step S603.

[00556] (Step S602) The drive control section 311 determines whether or not the area in which the data is actually recorded in step S112 is a contiguous range in the physical address space.

[00557] For example, the size of the area in which the data is actually recorded in step S112 is equal to the size of the area specified by the recording instruction, the drive control section 311 determines that the area in which the data is actually recorded in step S112 is a contiguous range in the physical address space.

- [00558] If the determination result in step S602 is "Yes", then the process proceeds to step S604. If the determination result in step S602 is "No", then the process proceeds to step S603.
- [00559] (Step S603) The drive control section 311 performs the process described with reference to Figure 19A, for example.
- [00560] (Step S604) The drive control section 311 determines whether the pseudo-overwrite recording is a first time replacement recording or a second time or replacement recording.
- [00561] Such a determination is performed, for example, by retrieving the latest replacement management information list to determine whether or not a first DFL entry 2010 (status 2 2011B = "0001") and a second DFL entry 2010 (status 2 2011B = "0010"), each of which having original location information indicating the same area as the contiguous range determined in step S601, are found in the replacement management information list.
- [00562] When the first DFL entry 2010 and the second DFL entry 2010 are not found in the replacement management information list, it is determined that the pseudo-overwrite recording is a first time replacement recording. As a result, the process proceeds to step S605.
- [00563] When the first DFL entry 2010 and the second DFL entry 2010 are found in the replacement management information list, it is determined that the pseudo-overwrite recording is a second time or more replacement recording. As a result, the process proceeds to step S607.
- [00564] (Step S605) The drive control section 311 creates new first DFL entry 2010 and a new second DFL entry 2010 and stores them in the memory circuit 312.

- [00565] (Step S606) The drive control section 311 sets values to the first DFL entry 2010 and the second DFL entry 2010.
- [00566] A value of "0000" indicating that the replacement recording is performed and there exists a replacement cluster is set to the status 1 2011A of the first DFL entry 2010.
- [00567] A value of a first PSN of the ECC cluster including a start location of the area specified by the recording instruction is set to the defective cluster first PSN 2012 of the first DFL entry 2010.
- [00568] A value of a first PSN of the ECC cluster including a start location of the contiguous range in which the data is actually recorded is set to the replacement cluster first PSN 2013 of the first DFL entry 2010.
- [00569] A value of "0001" indicating a start location of the contiguous range is set to the status 2 2011B of the first DFL entry 2010.
- [00570] A value of "0000" indicating that the replacement recording is performed and there exists a replacement cluster is set to the status 1 2011A of the second DFL entry 2010.
- [00571] A value of a first PSN of the ECC cluster including an end location of the area specified by the recording instruction is set to the defective cluster first PSN 2012 of the second DFL entry 2010. The end location of the area specified by the recording instruction is calculated, for example, by the physical address corresponding to the logical address and the length of the data to be recorded, which are specified by the recording instruction.
- [00572] A value of a first PSN of the ECC cluster including an end location of the contiguous range in which the data is actually recorded is set to the replacement cluster first PSN 2013 of the second DFL entry 2010.

- [00573] A value of "0010" indicating an end location of the contiguous range is set to the status 2 2011B of the second DFL entry 2010.
- [00574] (Step S607) The drive control section 311 performs an update process for the first DFL entry 2010 and the second DFL entry 2010 found in step S604. Specifically, the update process is performed by setting values to the first DFL entry 2010 and the second DFL entry 2010 in step S608.
- [00575] (Step S608) The drive control section 311 sets values to the first DFL entry 2010 and the second DFL entry 2010.
- [00576] A value of a first PSN of the ECC cluster including a start location of the contiguous range in which the data is actually recorded is set to the replacement cluster first PSN 2013 of the first DFL entry 2010. That is, the start location of a new replacement range is set.
- [00577] It is not necessary to update the defective cluster first PSN 2012 of the first DFL entry 2010, since the second time or more replacement recording is performed for the same ECC cluster. The defective cluster first PSN 2012 of the first DFL entry 2010 maintains the same value.
- [00578] A value of a first PSN of the ECC cluster including an end location of the contiguous range in which the data is actually recorded is set to the replacement cluster first PSN 2013 of the second DFL entry 2010. That is, the end location of a new replacement range is set.
- [00579] It is not necessary to update the defective cluster first PSN 2012 of the second DFL entry 2010, since the second time or more replacement recording is performed for the same ECC cluster. The defective cluster first PSN 2012 of the second DFL entry 2010 maintains the same value.

[00580] (Step S609) According to the process mentioned above, the replacement management information list is updated. That is, a new first DFL entry 2010 and a new second DFL entry 2010 are added to the replacement management information list or the existing first DFL entry 2010 and the existing second DFL entry 2010 in the replacement management information list are updated.

[00581] Then, the replacement management information list is sorted. For example, the replacement management information list is sorted by the status 1 2011A. Further, the replacement management information list may be sorted by the defective cluster first PSN 2012, the status 2 2011B and the replacement cluster first PSN 2013, in this order.

[00582] The process of step S113 shown in Figure 8A is terminated. The latest replacement management information list obtained in the process is additionally recorded in the (temporary) disc management information area.

[00583] In the exemplary process, a case is described where the replacement recording for the pseudo-overwrite recording is performed. However, the process can be also applied to the replacement recording due to the occurrence of the defective cluster.

[00584] With reference to Figures 20A to 24B, the procedure of the data recording will be further described.

[00585] Figure 20A shows a physical address space and a logical address space on the information recording medium 100, which is similar to Figure 13A and the like. Figure 20A shows a state in which data "A0" is recorded at the location of LSN=0 immediately after the formatting process. In the physical space, data "A0" is recorded in the location of PSN=1000.

[00586] The location of LSN=0 and the location of PSN=1000 maintain the relationship of the primary logical address-physical address mapping.

[00587] Figure 20B shows a replacement management information list corresponding to Figure 20A. The replacement management information list includes header information 1001 only and does not include any replacement management information.

[00588] In the state shown in Figure 20A, it is assumed that the drive apparatus 310 is instructed by the host apparatus 305 to record data "A1" at the location of LSN=0.

[00589] Figure 21A shows a state in which the recording of data "A1" is completed.

[00590] As shown in Figure 21A, data "A1" is recorded at the location of PSN=1132 in the user data area 108 instead of the location of PSN=1000 in the user data area 108, for example. This is because the data has been already recorded at the location of PSN=1000.

[00591] This replacement recording is a first time replacement recording. Accordingly, in accordance with step S302 and the subsequent steps shown in Figure 19A, the process for the first time replacement recording is performed. As a result, the DFL entry 2100A shown in Figure 21B is added to the replacement management information list.

[00592] Next, in the state shown in Figure 21A, it is assumed that the drive apparatus 310 is instructed by the host apparatus 305 to record data "A2" at the location of LSN=0.

[00593] Figure 22A shows a state in which the recording of data "A2" is completed.

[00594] As shown in Figure 22A, data "A2" is recorded at the location of PSN=1164 in the user data area 108 instead of the location of PSN=1000 in the user data area

108, for example. This is because the data has been already recorded at the location of PSN=1000.

[00595] This replacement recording is a second time or more replacement recording. Accordingly, in accordance with step S304 and the subsequent steps shown in Figure 19A, the process for the second time or more replacement recording is performed. As a result, the DFL entry 2100A is updated to the DFL entry 2100B shown in Figure 22B. That is, any DFL entry is not added to the replacement management information list.

[00596] Next, in the state shown in Figure 22A, it is assumed that the drive apparatus 310 is instructed by the host apparatus 305 to record data "B0" at the location of LSN=96 and to record data "C0" at the location of LSNs=128 to 192.

[00597] Figure 23A shows a state in which the recording of data "B0" and data "C0" is completed.

[00598] As shown in Figure 23A, it is assumed that an error occurs during the verify process for verifying the recording of data "B0" at the location of PSN=1192.

[00599] In this case, data "B0" is recorded at the location of PSN=x10 in the outer spare area 107 instead of the location of PSN=1193 in the user data area 108, for example.

[00600] This replacement recording is a first time replacement recording. Accordingly, in accordance with step S302 and the subsequent steps shown in Figure 19A, the process for the first time replacement recording is performed. As a result, the DFL entry 2101A shown in Figure 23B is added to the replacement management information list.

[00601] It is assumed that the verify process for verifying the recording of data "C0" has been successfully completed. In this case, the replacement management information list is maintained without any change.

[00602] Next, in the state shown in Figure 23A, it is assumed that the drive apparatus 310 is instructed by the host apparatus 305 to record data "C1" at the location of LSNs=128 to 192.

[00603] Figure 24A shows a state in which the recording of data "C1" is completed.

[00604] As shown in Figure 24A, data "C1" is recorded at the location of PSNs=1324 to 1388 in the user data area 108 instead of the location of PSNs=1288 to 1292 in the user data area 108, for example. This is because the data has been already recorded at the location of PSNs=1288 to 1292.

[00605] This replacement recording is a first time replacement recording. Accordingly, in accordance with step S302 and the subsequent steps shown in Figure 19A, the process for the first time replacement recording is performed. As a result, the DFL entry 2102A and the DFL entry 2103A shown in Figure 24B are added to the replacement management information list.

[00606] This replacement recording is based on a replacement of the contiguous range 2200 (PSNs= 1228 to 1292) with the contiguous range 2201 (PSNs=1324 to 1388). The replacement is represented using the DFL entry 2012A indicating start location of the replacement range and the DFL entry 2103A indicating end location of the replacement range.

[00607] Thus, in the pseudo-overwrite recording which replaces the contiguous range 2200 with the contiguous range 2201 in the user data area 108, the drive apparatus 310 generates a first replacement management information (DFL entry 2102A) for mapping the start location of the contiguous range 2200 to the start location of the

contiguous range 2201 and a second replacement management information (DFL entry 2103A) for mapping the end location of the contiguous range 2200 to the end location of the contiguous range 2201.

[00608] Although the replacement recording is performed for the contiguous range including three ECC clusters, only two DFL entries are added to the replacement management information list. This is an effect obtained by using the DFL entry 2102A and the DFL entry 2103A which map the contiguous range 2200 to the contiguous range 2201 in the user data area 108.

[00609] Regarding the replacement of the contiguous range, when the pseudo-overwrite recording is a second time or more replacement recording, it is needless to say that the existing DFL entries are updated.

[00610] (Embodiment 2)

[00611] 2-1. Procedure of NWA determining process

[00612] Hereinafter, a method for determining a next writable address represented by a logical address (hereinafter, "logical NWA") will be described. The drive device 310 returns the logical NWA back to the host apparatus 305 in response to a request from the host apparatus 305.

[00613] The logical NWA is determined in accordance with the following procedure in the present invention.

[00614] An ECC cluster which is next to the ECC cluster including the physical sector indicated by the LRA is determined. This ECC cluster is a next writable ECC cluster. The first physical sector of the next writable ECC cluster is a next writable address. The next writable address represented by a physical address is the NWA described above.

- [00615] The logical NWA has a value which is obtained by translating the value of the PSN indicated by the NWA into a value of the LSN in accordance with the primary logical address-physical address mapping.
- [00616] Several specific examples will be described below.
- [00617] In the state shown in Figure 12, the LRA 500 indicates a leading position of the user data area 108. In this state, the NWA in the physical address space is PSN=1100. The LSN corresponding to PSN=1000 is LSN=0. Therefore, the logical NWA=0.
- [00618] In Figure 13A, the host apparatus 305 obtains the logical NWA from the drive apparatus 310 and instructs the drive apparatus 310 to record data "A" at the location of LSN=0.
- [00619] In the state immediately after the recording of data "A" is completed, the LRA of the track #1 indicates an ECC cluster including the location of PSN=1132. In this state, the NWA is PSN=1132. Accordingly, the logical NWA is LSN=32. The host apparatus 305 can instruct the drive apparatus 310 to record data "B" at the logical NWA (i.e. LSN=32).
- [00620] In the state immediately after the recording of data "B" is completed, the LRA of the track #1 indicates a physical sector within an ECC cluster including the location of PSN=1132. In this state, the NWA is PSN=1164. Accordingly, the logical NWA is LSN=64.
- [00621] The feature of the method for determining a logical NWA described above is to determine the logical NWA to maintain the relationship of the primary logical address-physical address mapping. Specifically, the NWA is determined from the LRA within a track and then the logical NWA is obtained in accordance with the

primary logical address-physical address mapping. As a result, the replacement management information 1010B is not required for the new data recording.

[00622] In Figure 14A, it is possible that the host apparatus 305 erroneously holds a value corresponding to the LRA 501B as the logical NWA, even through the actual latest logical NWA should correspond to the LRA 500B.

[00623] For example, such a state may be caused when the drive apparatus 310 performs a recording operation for recording data at the location after PSN=1292 as an operation independent of the host apparatus 305 and the host apparatus 305 does not obtain the latest logical NWA from the drive apparatus 310.

[00624] In this state, when the host apparatus 305 instructs the drive apparatus 310 to record new data, the host apparatus 305 outputs a recording instruction for recording data at the logical NWA corresponding to the LRA 501B. However, the drive apparatus 310 records the data at the location of PSN=1336.

[00625] This recording causes a replacement recording. Accordingly, new replacement management information is required.

[00626] On the other hand, when the host apparatus 305 instructs the drive apparatus 310 to record new data, after it obtains the logical NWA corresponding to the latest LRA 500B from the drive apparatus 310, the recording does not cause any replacement recording. Accordingly, any new replacement management information is not required.

[00627] In Figures 15A and 16A, a similar state may be caused. In Figures 15A and 16A, it is possible that the host apparatus 305 erroneously holds a value corresponding to the LRA 501C as the logical NWA, even through the actual latest logical NWA should correspond to the LRA 5000 and the LRA 500D.

[00628] Therefore, it is desirable that the host apparatus 305 obtains the latest logical NWA before recording a new data.

[00629] In summary, when the host apparatus 305 instructs the drive apparatus 310 to record new data, the host apparatus 305 outputs a request to the drive apparatus 310 immediately before step S102 shown in Figure 8A, for example, in order to obtain the latest logical NWA from the drive apparatus 310. Upon receipt of the request, the drive apparatus 310 determines the logical NWA from the LRA and the NWA in accordance with the process described above and returns the logical NWA back to the host apparatus 305.

[00630] Upon receipt of the logical NWA, the host apparatus 305 generates a next recording instruction based on the logical NWA and outputs the next recording instruction to the drive apparatus 310.

[00631] By performing the operations described above, the replacement management information 1010B is not required for recording new data. The replacement management information 1010B is required for performing the replacement recording only.

[00632] As a result, it is possible to restrict increasing the data amount of the replacement management information list 1000. This provides an effect such as the reduction of the amount of processing in the data recording/reproduction, the reduction of the size of the memory, the reduction of the data size on the information recording medium 100 and the like.

[00633] (Embodiment 3)

[00634] 3-1. Procedure of recording process (1)

[00635] A method for determining NWA described in the embodiment 2 causes a state in which a particular LSN is not used.

[00636] For example, in Figure 14A, the logical sector at the location of LSN=96 is a logical sector in which any data has not been recorded when it is seen from the host apparatus 305 or the file system.

[00637] Such a logical sector is referred to as an unrecorded logical sector or a unused logical sector, an orphan logical sector and the like.

[00638] A logical cluster consisting of the unrecorded logical sectors is referred to as an unrecorded logical cluster. For example, in Figure 14A, the logical cluster corresponding to the location of LSNs=96 to 127 is an unrecorded logical cluster.

[00639] Similarly, in Figure 15A, the logical sector corresponding to the location of LSN=X2 is an unrecorded logical sector.

[00640] As shown in Figure 14A and the like, the LSNs are assigned to the unrecorded logical sectors in the same manner as other normal logical sectors. Further, it is the feature of the method for determining logical NWA according to the present embodiment that the LSNs of the logical sectors subsequent to the unrecorded logical sector are not changed.

[00641] When it is instructed to record data at the unrecorded logical sector, the pseudo-overwrite recording is performed in a similar manner as the embodiments described above. For example, the following process is performed.

[00642] Herein, in the state shown in Figure 14A, it is assumed that it is instructed to record data "F" at the location of LSN=96.

[00643] In this case, the drive apparatus 310 translates LSN=96 into PSN=1196 in accordance with the primary logical address-physical address mapping.

[00644] By comparing the location of PSN=1196 with the location indicated by the NWA, it is recognized that the data is recorded at the location of PSN=1196.

[00645] Then, the pseudo-overwrite recording is performed in a similar manner as the other embodiments described above.

[00646] In this case, the drive apparatus 310 records data "F" at the location indicated by the NWA (e.g. the location of PSN=1336) and generates replacement management information 518.

[00647] Thus, the data recording is performed for the location of LSN=96. As a result, a logical cluster corresponding to the location of LSN=96 changes from the unrecorded logical cluster to the normal logical cluster.

[00648] A logical cluster corresponding to the location of LSNs=256 to 287 associated with the location of PSN=1336 in accordance with the primary logical address-physical address mapping newly becomes an unrecorded cluster.

[00649] Figures 17A and 17B show a state after the recording of data "G" is completed.

[00650] 3-2. Procedure of reproduction process (1)

[00651] In Figure 14A, the logical cluster at the location of LSN=224 is an unrecorded logical cluster.

[00652] The physical cluster corresponding to the unrecorded logical cluster at the location of LSN=223 is a physical cluster at the location of PSN=1324. The relationship between the LSNs and the PSNs are predetermined in accordance with the primary logical address-physical address mapping.

[00653] The physical cluster at the location of PSN=1324 is related to the physical cluster at the location of PSN=1228 by the replacement management information 514.

[00654] The physical cluster at the location of PSN=1228 is mapped to the logical cluster at the location of LSN=128 in accordance with the primary logical address-physical address mapping.

[00655] Thus, the physical cluster at the location of PSN=1228 is assigned to the logical cluster at the location of LSN=128 and the unrecorded logical cluster at the location of LSN=224.

[00656] The procedure of the reproduction process will be described in a case where two logical clusters are assigned to one physical cluster.

[00657] The host apparatus 305 outputs a reproduction instruction for the location of LSN=128 to the drive apparatus 310. Upon the receipt of the reproduction instruction, the drive apparatus 310 translates the LSN into the PSN in accordance with the primary logical address-physical address mapping. The PSN is referred to as a reproduction PSN.

[00658] In this case, the reproduction PSN is PSN=1228. Replacement management information having the location of PSN=1228 as the replacement location is retrieved in the replacement management information list. As a result, the replacement management information 514A is found.

[00659] The replacement cluster indicated by the replacement management information 514A is a physical cluster at the location of PSN=1324. The data recorded in the physical cluster at the location of PSN=1324 is reproduced.

[00660] The host apparatus 305 outputs a reproduction instruction for the location of LSN=224 to the drive apparatus 310. Upon the receipt of the reproduction instruction, the drive apparatus 310 translates the LSN into the reproduction PSN in accordance with the primary logical address-physical address mapping.

[00661] In this case, the reproduction PSN is PSN=1324. Replacement management information having the location of PSN=1324 as the replacement location is retrieved in the replacement management information list. However, such replacement management information is not found.

[00662] The drive apparatus 310 reproduces data recorded in the physical cluster at the location of PSN=1324.

[00663] According to the reproduction process described above, when the host apparatus 305 outputs a reproduction instruction for the location of an unrecorded logical sector in which any data has not been logically recorded, it is possible to reproduce data recorded in the physical sector corresponding to the unrecorded logical sector.

[00664] As a result, it is seen from the file system and the like at the side of the host apparatus 305 that there is no exceptional area on the information recording medium 100. Further, it is not necessary to implement a complex error process in the system structure. It is possible to configure the system with a simplified implementation.

[00665] Upon the receipt of a reproduction instruction for an unrecorded logical sector, if the drive apparatus 310 reproduces data recorded in the physical cluster corresponding to the unrecorded logical sector, then the data which should not be essentially reproduced is reproduced. If such a reproduction is inconvenient for the system configuration, it is possible to adopt the following procedure for the reproduction process.

[00666] The drive apparatus 310 translates the LSN specified by the reproduction instruction into a PSN in accordance with the primary logical address-physical address mapping, and retrieves the replacement management information 1010B

having the original location information 1012 corresponding to the translated PSN in the replacement management information list 1000.

[00667] If the replacement management information 1010B having the original location information 1012 corresponding to the translated PSN is found, the data is reproduced from the ECC cluster at the replacement location indicated by the replacement location information 1013 of the replacement management information 1010B in a similar manner as the other embodiments described above.

[00668] If it is not found, the drive apparatus 310 retrieves the replacement management information 1010B having the replacement location information 1013 corresponding to the translated PSN in the replacement management information list 1000.

[00669] If the replacement management information 1010B having the replacement location information 1013 corresponding to the translated PSN is found, the ECC cluster indicated by the replacement location information 1013 is determined as the replacement cluster in which the data has been already recorded.

[00670] Then, the drive apparatus 310 does not reproduce the data from the replacement cluster. Instead, the drive apparatus 310 returns a predetermined data (e.g. data having a value of "00...0") as the reproduced data back to the host apparatus 305.

[00671] According to the reproduction process described above, when it is instructed to reproduce data from the unrecorded logical sector, the data can be reproduced appropriately from the physical sector corresponding to the unrecorded logical sector.

[00672] Such a reproduction process can be performed when the drive apparatus 310 receives the reproduction instruction from the host apparatus 305 in each step of the reproduction process described with reference to Figure 10.

[00673] 3-3. Comparison between procedures of NWA determining process

[00674] Unlike the embodiment described above, a method for determining a logical NWA will be described. In this method, any unrecorded logical sector does not occur.

[00675] In this method, the logical LRA is managed, and a new data is recorded at the logical NWA which is adjacent to the logical LRA.

[00676] The LSN indicating the logical NWA is translated into a PSN in accordance with the primary logical address-physical address mapping. The translated PSN is referred to as "PSN-1".

[00677] The data is actually recorded at the NWA within an ECC cluster which is next to the ECC cluster including the PSN indicated by the LRA 213. The PSN indicated by the NWA is referred to as "PSN-2".

[00678] The replacement recording is performed with the original location of PSN-1 and the replacement location of PSN-2.

[00679] Figure 25 shows a data structure of the track management information 3210 according to the present embodiment. The track management information 3210 is used to manage the logical NWA.

[00680] In the track management information 3210 shown in Figure 25, last recorded logical address information within track 3214 is newly defined.

[00681] The last recorded logical address information within track 3214 is used to manage the last recorded address represented by LSN in the logical address space, whereas the last recorded address information within track (LRA) 213 is used to

manage the last recorded address represented by PSN in the physical address space.

[00682] The drive apparatus 310 can determine the logical NWA for each track by referring to the last recorded logical address information within track 3214.

[00683] The last recorded logical address information within track 3214 is updated in the following manner.

[00684] The value of "0" is set to the last recorded logical address information within track 3214 as an initial value. The drive apparatus 310 receives a recording instruction including a LSN. When the LSN in the recording instruction is greater than the last recorded logical address information within track 3214, the drive apparatus 310 updates the last recorded logical address information within track 3214 to the LSN.

[00685] According to the update process described above, it is possible to maintain the last recorded logical address information within track 3214 as being a maximum value.

[00686] Figure 26A shows a data structure after the recording of data "A", "B", "C", "D", "F" and "G" are completed in the same order as in Figures 13A, 14A and 17A in accordance with the procedure of NWA determining process described above.

[00687] In Figure 26B, all of defective clusters are registered as the replacement management information (7). However, it is possible to delete these replacement management information (7) from the replacement management information list 1000F. By deleting these, the size of the replacement management information list 1000F can be reduced.

[00688] By comparing the replacement management information list 1000E shown in Figure 17B with the replacement management information list 1000F shown in

Figure 26B, it is understood that the number of the replacement management information in the replacement management information list 1000E is smaller than the number of the replacement management information in the replacement management information list 1000F.

[00689] By comparing these lists after deleting replacement management information (7), it is also understood that the number of the replacement management information in the replacement management information list 1000E is much smaller than the number of the replacement management information in the replacement management information list 1000F.

[00690] Accordingly, the method for determining NWA while allowing the occurrence of the unrecorded logical sector as described in embodiment 1 and embodiment 2 is more desirable rather than the method which refers to Figure 26A while not allowing the occurrence of the unrecorded logical sector in that the size of replacement management information list can be reduced.

[00691] By maintaining the replacement management information (7) in the replacement management information list 1000F, it is possible to recognize the distribution of the defective clusters on the information recording medium 100. The distribution of the defective clusters can be used to optimize the reproduction process. Such an optimization is made, for example, by reading data in advance without reading data from the defective sectors.

[00692] (Embodiment 4)

[00693] The procedure of the data recording according to the present embodiment will be described.

[00694] Figure 27 shows an exemplary data structure of the information recording medium 100 before performing the data recording according to the present

embodiment. In Figure 27, each symbol of triangle indicates a boarder between the ECC clusters. Hereinafter, even in other figures, each symbol of triangle has the same meaning.

[00695] In the state shown in Figure 27, it is assumed that the host apparatus 305 outputs a recording instruction for data "D1" 4622 and data "E1" 4623 to the drive apparatus 310. In this case, the procedure of the recording process will be described.

[00696] The data recording for data "D1" 4622 is determined as the pseudo-overwrite recording at the location of PSN=a0 in the recorded area 4600, for example.

[00697] Prior to outputting the recording instruction, the host apparatus 305 outputs a request for the logical NWA to the drive apparatus 310.

[00698] Upon the receipt of the request for the logical NWA, the drive apparatus 310 determines NWA 4611A from LRA 4610A and returns the logical NWA corresponding to the NWA 4611A back to the host apparatus 305.

[00699] The host apparatus 305 outputs a recording instruction for recording data "D1" 4622 at the location of LSN=A0 corresponding to PSN=a0 to the drive apparatus 310, and then outputs a recording instruction for recording data "E1" 4623 at the location of LSN=A2 corresponding to NWA 4611A (PSN=a2) to the drive apparatus 310.

[00700] Figure 28 shows a recording result after the drive apparatus 310 performs a recording process for data "D1" 4622 and a recording process for data "E1" 4623 in accordance with the order of the recording instructions as instructed by the host apparatus 305.

[00701] In this case, the data recording for data "D1" 4622 is determined as the pseudo-overwrite recording for the recorded area 4600. As a result, data "D1" 4622

is recorded at the location of NWA 4611A (PSN=a2) instead of the location of PSN=a0. Then, the NWA 4611A is updated to the NWA 4611B (PSN=a3).

[00702] As a result of this replacement recording, data "D1" 4622 is recorded at the location of PSN=a2. As a result, data "E1" 4623 is recorded at the location of NWA 4611B (PSN=a3) instead of the location of PSN=a2.

[00703] Thus, although the host apparatus 305 outputs a recording instruction for recording data "E1" 4623 at the location of LSN=A2 corresponding to NWA 4611A (PSN=a2) as described above, data "E1" 4623 is recorded at the location of PSN=a3 which is deferent from the location as instructed.

[00704] In this case, the replacement management information 1010 for data "D1" 4622 is generated, and the replacement management information 1010 for data "E1" 4623 is also generated. This causes a problem that the size of the replacement management information list 1000 is increased.

[00705] This problem is caused by the drive apparatus 310 performing the replacement recording which is not expected by the host apparatus 305.

[00706] After performing the replacement recording by the drive apparatus 310, it is necessary to perform further replacement recording as the host apparatus 305 outputs a recording instruction. This results in increasing the size of the replacement management information list 1000.

[00707] Hereinafter, a method according to the present embodiment will be described. In this method, the replacement management information 1010 for data "E1" 4623 is not generated during the recording process.

[00708] In the present embodiment, in the state shown in Figure 27, the host apparatus 305 first outputs a recording instruction for the appending recording. Then, the host apparatus 305 outputs a recording instruction for the pseudo-

overwrite recording after outputting the recording instruction for the appending recording.

[00709] Figure 29 shows a recording result after the drive apparatus 310 performs recording processes in accordance with the order of the recording instructions as instructed by the host apparatus 305.

[00710] The file system operating on the host apparatus 305 can determine the order of the recording instructions, since it manages updating all existing files and creating new files.

[00711] In Figure 29, data "E1" 4623B is recorded at the location of NWA 4611A (PSN=a2), and data "D1" 4622B is recorded at the location of PSN=a4.

[00712] The host apparatus 305 outputs a recording instruction for recording data "E1" 4623B at the location of NWA 4611A (PSN=a2) as described above. In the present embodiment, data "E1" 4623B is recorded at the location of PSN=a2 which is the same as the location as instructed. This data recording is not a replacement recording.

[00713] Thus, the replacement management information 1010 for data "E1" 4623B is not generated. As a result, it is possible to avoid increasing the size of the replacement management information list 1000.

[00714] In either case shown in Figure 28 or the case shown in Figure 29, the same number of the replacement management information 1010 is required in order to record data "D1" 4622. Although the recording location (i.e. replacement location) of data "D1" 4622 are different from each other in Figures 28 and 29, the required number of the replacement management information 1010 is maintained.

[00715] As described above, when the host apparatus 305 instructs the drive apparatus 310 to perform both of the pseudo-overwrite recording and the appending

recording, the host apparatus 305 outputs a recording instruction for the appending recording to the drive apparatus 310 prior to outputting a recording instruction for the pseudo-overwrite recording to the drive apparatus 310. This makes it possible to avoid generating the replacement management information 1010, thereby reducing the size of the replacement management information list 1000.

[00716] (Embodiment 5)

[00717] Herein, it is assumed the host apparatus 305 divides data having a size into a plurality of portions, such that each of the plurality of portions has a size of one ECC cluster. It is also assumed that the host apparatus 305 sequentially outputs a recording instruction for each portion of the data as a recording unit to the drive apparatus 310.

[00718] The drive apparatus 310 records the respective portions of the data contiguously. It is assumed that a defective cluster including the recording location is detected, and a cluster which is adjacent to the defective cluster is used as a replacement cluster in order to replace the defective cluster with the replacement cluster.

[00719] In this case, the replacement recording is required for each recording unit after the recording location. In the replacement recording, each cluster is replaced by an adjacent cluster which is located in a direction along which the PSNs increase.

[00720] In this case, the replacement management information is required for each recording unit. Accordingly, when the size of data to be recorded is very large, the large number of replacement management information is required, thereby increasing the size of the replacement management information list 1000.

[00721] Hereinafter, a method according to the present embodiment will be described with reference to Figure 30. This method is effective to reduce the size of the replacement management information list 1000.

[00722] In Figure 30, a replacement recording is performed in accordance with the recording instruction from the host apparatus 305. In the replacement recording, it is assumed that the original location is original cluster 5700.

[00723] The replacement location of the replacement recording is determined in the following manner.

[00724] In Figure 30, the replacement cluster maybe allocated in one of the unrecorded area 5601A (in track #N 5602), the unrecorded area 5612 (in track #N+1 5610), the unrecorded area 5622 (in track #N+2 5620) and the unrecorded area 5632 (in track #N+3 5630). Each of these unrecorded areas is a candidate area for the replacement cluster.

[00725] Herein, a distance between the location of the original cluster 5700 (e.g. the location of the first physical sector in the original cluster 5700) and the location of the candidate area for the replacement cluster (e.g. the location of the NWA in the open track) is evaluated. The respective distances with respect to the respective candidate areas for the replacement cluster are D13, D12, D10 and D11, as shown in Figure 30.

[00726] It is assumed that the respective distances satisfy the relationship of $D13 > D12 > D11 > D10$.

[00727] By selecting the unrecorded area 5622 which has a minimum distance D10 as an area for the replacement cluster, it is possible to minimize a distance between the original cluster and the replacement cluster. As a result, it is possible to minimize an access time in the data reproduction.

[00728] However, the unrecorded area 5622 is included in the same track #N+2 5620 as the original cluster 5700. Accordingly, when the unrecorded area 5622 is selected as an area for the replacement cluster, it may cause a problem that the size of the replacement management information list 1000 is increased in the case where the drive apparatus 310 sequentially receives a plurality of recording instructions from the host apparatus 305 as described above.

[00729] According to the present embodiment, an unrecorded area which has a minimum distance from the original cluster is selected as an area for the replacement cluster. However, during the selection process, an unrecorded area included in the same track as the original cluster is excluded from the selection.

[00730] In Figure 30, the unrecorded area 5622 which has a minimum distance D10 is excluded from the selection. The unrecorded area 5632 which has the next minimum distance D11 is selected as an area for the replacement cluster.

[00731] Thus, upon receipt of the recording instruction for the original cluster 5700 from the host apparatus 305, the drive apparatus 310 allocates the replacement cluster 5710 at the location of NWA in the unrecorded area 5632 and records data in the replacement cluster 5710.

[00732] The drive apparatus 310 generates the replacement management information which maps the original cluster 5700 to the replacement cluster 5710 and records the replacement management information.

[00733] As described in steps S107 and S112 (Figure 8A) , when the drive control section 311 according to the present invention performs the pseudo-overwrite recording, it controls the recording/reproduction section 314 to record data at a specific location in the user data area 108, which is other than the location indicated

by the physical address corresponding to the logical address included in the received recording instruction.

[00734] In the present embodiment, the specific location is the NWA within an open track which is different from the track determined in step S104 (Figure 8A).

[00735] Further, the NWA within the open track indicates a location which is the closest to the location indicated by the physical address corresponding to the logical address included in the recording instruction.

[00736] According to the procedure of the recording process, even if the host apparatus 305 further outputs a recording instruction to the drive apparatus 310, the data recording for the unrecorded area 5622 does not cause any replacement recording. The addition of the replacement management information is not required.

[00737] A distance between the original location and the replacement location becomes minimum, except for a case where the original location and the replacement location are included in the same track. As a result, it is possible to reduce an access time in the data reproduction.

[00738] The drive apparatus 310 may determine the location of the replacement cluster by evaluating a distance between the original cluster and an unrecorded area which has PSNs greater than the PSNs of the original cluster. In the write-once recording mediums, a sequential recording is performed in a direction along which the PSNs increase. Accordingly, it is possible to efficiently access data by replacing the original cluster with the replacement cluster which has PSNs greater than the PSNs of the original cluster.

[00739] In this case, if there is no remaining unrecorded area which has PSNs greater than the PSNs of the original cluster, then the drive apparatus 310 may determine the location of the replacement cluster by evaluating a distance between

the original cluster and an unrecorded area which has PSNs smaller than the PSNs of the original cluster.

[00740] When there are a plurality of unrecorded areas which have the same distance from the original cluster, it is desirable to select one of the plurality of unrecorded areas, which has PSNs greater than the PSNs of the original cluster. In the write-once recording mediums, a sequential recording is performed in a direction along which the PSNs increase. Accordingly, it is possible to efficiently access data by replacing the original cluster with the replacement cluster which has PSNs greater than the PSNs of the original cluster.

[00741] The distance between the original location and the replacement location may be determined from a difference between a PSN indicating the original location and a PSN indicating the replacement location. Alternatively, the distance may be determined from a physical distance between the original location and the replacement location. This is because the difference between the PSNs does not necessarily correspond to the physical distance, since the PSNs increase from the inner side to the outer side in a spiral manner in the information recording medium 100. For example, with respect to ECC clusters which are adjacent to each other in a radius direction, even if the physical distance is close to zero, the difference between the PSNs does not become minimum.

[00742] (Embodiment 6)

[00743] With reference to Figure 34, a procedure of data recording according to the present embodiment will be described. In this embodiment, the information recording/reproduction apparatus 300 shown in Figure 6 is used for recording data on the information recording medium 100. The steps shown in Figure 34 are performed by the drive control section 311 of the drive apparatus 310.

[00744] (Step S1101) The drive control section 311 receives a recording instruction from a host apparatus 305. The recording instruction designates data to be recorded, and a logical address indicating a location where the data is to be recorded.

[00745] This process is the same as the process of step S102 shown in Figure 8A.

[00746] (Step S1102) The drive control section 311 translates the logical address included in the recording instruction into a physical address. Such translation is performed in accordance with, for example, the primary logical address-physical address mapping.

[00747] This process is the same as the process of step S103 shown in Figure 8A.

[00748] (Step S1103) The drive control section 311 determines one of at least one tracks allocated to a user data area 108. Such determination is made based on, for example, the physical address corresponding to the logical address included in the recording instruction, and track management information 210 (Figure 2B) included in disc management information. The track management information 210 indicates a range of the tracks on a data area 102. Thus, if a physical address is known, the corresponding track can be determined.

[00749] This process is the same as the process of step S104 shown in Figure 8A.

[00750] (Step S1104) The drive control section 311 determines whether the track determined in step S1103 is an open track or a closed track. Such determination is made based on, for example, the track management information 210 (Figure 2B). The header information 201 includes a track number of an open track. Therefore, any track having a track number which is not included in the header information 201 is a closed track.

[00751] See Embodiment 1 for the definition of the open track and for the definition of the closed track.

[00752] When the present invention is applied to the BD-R specification, the term "open track" in the present specification should be read as an open SRR, and the term "closed track" in the present specification should be read as a closed SRR.

[00753] In step S1104, when it is determined as an open track the process proceeds to step S1105, and when it is determined as a closed track, the process proceeds to step S1106.

[00754] (Step S1105) In this step, a recording process for the open track is performed. The recording process for the open track includes, for example, steps S105 to S114 shown in Figure 8A.

[00755] (Step S1106) In this step, a recording process for the closed track is performed. The recording process for the closed track includes, for example, steps S106 to S114 shown in Figure 8A.

[00756] More specifically, in the recording process for the closed track, the pseudo-overwrite recording is performed. In the case, the replacement location may be an NWA of an open track which is different from the closed track determined in step S1104.

[00757] Hereinafter, an exemplary process of the data recording shown in Figure 34 will be described.

[00758] Figure 35A shows an exemplary data structure of the information recording medium 100 before the data recording shown in Figure 34 is performed.

[00759] In the example shown in Figure 35A, track #N-1 and track #N are allocated to the user data area 108. In this example, the track #N-1 is an open track.

[00760] The track #N-1 includes a recorded area 6600 and an unrecorded area 6602.

[00761] In the state as shown in Figure 35A, it is assumed that the drive control section 311 received a recording instruction from the host apparatus 305. In this example, the recording instruction is an instruction for recording data "A" 6602 at a location of LSN=A1 (PSN=a1).

[00762] In the conventional sequential recording method, such a recording instruction causes a recording error because LSN=A1 is larger than NWA 6611A.

[00763] Alternatively, it is possible to define that such a recording instruction does not any a recording error. In this case, as shown in Figure 36A, dummy data or padding data (for example, with all the values being "00h") is recorded in an area from PSN=b1 to PSN=a1, and data "A" 6602 is recorded in a subsequent area. Such a process is achieved by, for example, inserting a step of recording dummy data or padding data immediately before step S112 shown in Figure 8A.

[00764] According to this method, data "A" 6602 is recorded at the location of PSN=a1. However, there is another problem that an extra operation, i.e., recording of padding data is required, or the capacity of the information recording medium 100 wasted.

[00765] Further, the method shown in Figure 36A can be used only when the track #N-1 is an open track since data is recorded additionally.

[00766] When the track #N-1 is a closed track, an appending recording is prohibited. Therefore, recording cannot be performed to a closed track by the method shown in Figure 36A.

[00767] In order to enable data recording irrespective of whether the track #N-1 is an open track or a closed track, for example, as shown in Figure 37A, data "A" 6602 may be recorded to a specific location in the spare area instead of recording data "A" 6602 at the location of PSN=a1.

[00768] In the example shown in Figure 37A, data "A" 6602 is recorded at the location of PSN=s1 in the inner spare area 106. Thus, in the example shown in Figure 37A, any data is not recorded in the track #N-1. As a result, the location of LRA 6610A is not updated.

[00769] The drive control section 311 generates replacement management information 6615 in order to map the physical address (i.e., PSN=a1) corresponding to the logical address included in the recording instruction to a physical address (i.e., PSN=s1) indicating the location where data "A" 6602 is actually recorded.

[00770] Figure 37B shows an exemplary data structure of the replacement management information 6615. The replacement management information 6615 includes a defective cluster first PSN 2012 as an original location address, and a replacement cluster first PSN 2013 as a replacement location address. In the defective cluster first PSN 2012 of the replacement management information 6615, the physical address corresponding to the logical address included in the recording instruction (i.e., PSN=a1) is set. In the replacement cluster first PSN 2013 of the replacement management information 6615, the physical address indicating the location where data "A" 6602 (i.e., PSN=s1) is actually recorded is set.

[00771] By generating such replacement management information 6615, even when the drive control section 311 receives, from the host apparatus 315, a reproduction instruction for reproducing the data from the location of LSN=A1, it is possible to reproduce data "A" 6602 from the location of PSN=s1, instead of the location of PSN=a1 corresponding to the location of LSN=A1.

[00772] Alternatively, when it is determined that the track #N-1 is an open track in step S1104, as shown in Figure 38A, data "A" 6602 may be recorded at a location of NWA 6611A of the track #N-1 (i.e., the location of PSN=b1). In this case, the LRA

6610A indicating the last recorded address within the track #N-1 is updated to the LRA 6610B as data "A" 6602 is recorded.

[00773] The drive control section 311 generates replacement management information 6616 in order to map the physical address corresponding to the logical address included in the recording instruction (i.e., PSN=a1) to the physical address indicating the location where data "A" 6602 is actually recorded (i.e., PSN=b1).

[00774] Figure 38B shows an exemplary data structure of replacement management information 6616. The structure of the replacement management information 6616 is same as the structure of the replacement management information 6615. In the defective cluster first PSN 2012 of the replacement management information 6616, the physical address corresponding to the logical address included in the recording instruction (i.e., PSN=a1) is set. In the replacement cluster first PSN 2013 of the replacement management information 6616, the physical address indicating the location where data "A" 6602 is actually recorded (i.e., PSN=b1) is set.

[00775] By generating such replacement management information 6616, even when the drive control section 311 receives, from the host apparatus 305, a reproduction instruction for reproducing data from the location of LSN=A1, it is possible to reproduce data "A" 6602 from the location of PSN=b1 instead of the location of PSN=a1 corresponding to the location of LSN=A1.

[00776] Alternatively, when it is determined that the track #N-1 is a closed track in step S1104, as shown in Figure 39A, data "A" 6602 may be recorded at a location of NWA of the open track which is different from the track #N-1.

[00777] In the example shown in Figure 39A, track #N which is adjacent to the track #N-1 is an open track. Thus, data "A" 6602 is recorded at a location of NWA 6621A

of the track #N. In this case, the LRA 6621A indicating the last recorded address within the track #N is updated to the LRA 6621B as data "A" 6602 is recorded.

[00778] The LRA 6611A indicating the last recorded address within the track #N-1 is not updated, since the track #N-1 is a closed track for which the data recording is instructed.

[00779] The open track different from the track #N is not limited to the track adjacent to the track #N. The open track different from the track #N may be any open track other than the track #N.

[00780] For example, the next writable address in an open track which is close to the physical address corresponding to the logical address included in the recording instruction is desirable in view of access performance.

[00781] The drive control section 311 generates replacement management information 7615 in order to map the physical address corresponding to the logical address included in the recording instruction (i.e., PSN=a1) to the physical address indicating the location where data "A" 6602 is actually recorded (i.e., PSN=b2).

[00782] Figure 39B shows an exemplary data structure of the replacement management information 7615. The structure of the replacement management information 7615 is same as the structure of the replacement management information 6615. In the defective cluster first PSN 2012 of the replacement management information 7615, the physical address corresponding to the logical address included in the recording instruction (i.e., PSN=a1) is set. In the replacement cluster first PSN 2013 of the replacement management information 7615, the physical address indicating the location where data "A" 6602 is actually recorded (i.e., PSN=b2) is set.

[00783] By generating such replacement management information 7615, even when the drive control section 311 receives, from the host apparatus 305, a reproduction instruction for reproducing data from the location of LSN=A1, it is possible to reproduce data "A" 6602 from the location of PSN=b2 instead of the location of PSN=a1 corresponding to the location of LSN=A1.

[00784] In either example shown in Figures 37A, 38A and 39A, areas used in the information recording medium 100 is only for the size of data "A" 6602 designated by the recording instruction, and there is no need to perform ineffective recording such as dummy data.

[00785] As described above, even when the physical address corresponding to the logical address included in the recording instruction is larger than the NWA, by performing replacement recording using replacement management information, recording error does not occur, and efficient data recording becomes possible.

[00786] Figure 40A shows an exemplary data structure of the information recording medium 100 before the data recording shown in Figure 34 is performed.

[00787] In the example shown in Figure 40A, track #N-1 and track #N are allocated to the user data area 108. In this example, the track #N-1 is a closed track including an unrecorded area 6701. The track #N is an open track.

[00788] In the track #N-1, data "A" 6700 has already been recorded. However, since the track #N-1 is a closed track, any appending recording to the track #N-1 is prohibited.

[00789] This is because, as described above, the closed track is defined as a track whose track number is not included in the header information 201. The closed track is a track for which additional data recording is prohibited.

[00790] Since the track #N is an open track, it is possible to appending record data in the track #N.

[00791] In the state shown in Figure 40A, it is assumed that the drive control section 311 receives a recording instruction from the host apparatus 305. In this example, it is assumed that the recording instruction is an instruction for recording data "A1" 6703A at a location of LSN=A1 (PSN=a1). The location of LSN=A1 (PSN=a1) is a location where data "A" 6700 has already been recorded. Accordingly, the recording instruction is determined as an instruction for pseudo-overwriting data "A1" 6703 on data "A" 6700.

[00792] Herein, it is assumed that data "A1" 6703A is recorded at a location of NWA 6711A (i.e., a location of PSN=a2) in an unrecorded area in the track #N-1, which is a closed track, as shown in Figure 41A.

[00793] In this case, the drive control section 311 generates replacement management information 6730 in order to map a physical address corresponding to the logical address included in the recording instruction (i.e., PSN=a1) and a physical address indicating the location where data "A1" 6703A is actually recorded (i.e., PSN=a2).

[00794] Figure 41B shows an exemplary data structure of the replacement management information 6730. The structure of the replacement management information 6730 is same as the structure of the replacement management information 6615. In the defective cluster first PSN 2012 of the replacement management information 6730, the physical address corresponding to the logical address included in the recording instruction (i.e., PSN=a1) is set. In the replacement cluster first PSN 2013 of the replacement management information

6730, the physical address indicating the location where data "A1" 6703A is actually recorded (i.e., PSN=a2) is set.

[00795] The LRA 6710A indicating the last recorded address within the track #N-1 is updated to the LRA 6710B as data "A1" 6703A is recorded. Thus, it is required to update the LRA within the closed track in order to record data in an unrecorded area of the closed track.

[00796] As the recording capacity of the information recording medium 100 increases, the number of the tracks which can be allocated to the user data area 108 becomes significantly large. Particularly, as for closed tracks, the number will not decrease once they are allocated. (On the other hand, the number of the open tracks may increase or decrease. For example, the number of the open tracks decreases when some of the open tracks become closed tracks.)

[00797] As a result, the update process of the LRA in the closed track may be a process having a significantly large process amount.

[00798] In order to avoid such a process with a large process amount, in the present embodiment, similarly to the data recording procedure described with reference to Figure 39A, when the track #N-1 is determined to be a closed track, data "A1" 6703A is recorded at a location of NWA of an open track different from the track #N-1 as shown in Figure 42A.

[00799] In the example shown in Figure 42A, the track #N adjacent to the track #N-1 is an open track. Thus, data "A1" 6703A is recorded at the location of NWA 6721A within track #N.

[00800] The drive control section 311 generates replacement management information 6733 in order to map the physical address corresponding to the logical

address included in the recording instruction (i.e., PSN=a1) to the physical address indicating the location where data "A1" 6703A is actually recorded (i.e., PSN=a3).

[00801] Figure 42B shows an exemplary data structure of the replacement management information 6733. The structure of the replacement management information 6733 is same as the structure of the replacement management information 6615. In the defective cluster first PSN 2012 of the replacement management information 6733, the physical address corresponding to the logical address included in the recording instruction (i.e., PSN=a1) is set. In the replacement cluster first PSN 2013 of the replacement management information 6733, the physical address indicating the location where data "A1" 6703A is actually recorded (i.e., PSN=a3) is set.

[00802] The LRA 6721A indicating the last recorded address within track #N is updated to the LRA 6721B as data "A1" 6703A is recorded. However, it is not necessary to update the LRA 6710A indicating the last recorded address within track #N-1. As described above, since data is recorded in an unrecorded area of an open track, a process for updating the LRA in a closed track is not required.

[00803] According to the data recording described above, it is possible to not manage the LRA 213 in the closed track while it is possible to perform the pseudo-overwrite recording for the closed track.

[00804] In Embodiment 1, it is described that recording of data may be implemented by an RMW process.

[00805] If it is determined that an end of the data designated by the recording instruction does not match a boundary of the ECC clusters, and that the physical address corresponding to the logical address included in the recording instruction is included in an unrecorded area of a closed track, then it is possible to insert padding

data (e.g., "00h") into the data to be recorded such that the end of the data to which the padding data is inserted matches the boundary of the ECC clusters. The data to which the padding data is inserted is recorded in the track.

[00806] (Embodiment 7)

[00807] As described above, in step S112 of Figure 8A, data is recorded to a location which is designated as a recording location. After data is recorded, a process for determining whether or not the data recording has succeeded is performed. Such a process is called a verify process. When it is determined that the data recording has failed as a result of the verify process, it may be said that a verify error occurs. The verify process is performed by, for example, reading the recorded data from the information recording medium 100, and determining whether or not the read data matches the data to be recorded.

[00808] In the replacement recording as described above, there may be a case where a verify error occurs when data is recorded in a replacement cluster in the user data area 108. In this case, the replacement cluster is regarded as a defective cluster, and a new replacement cluster is allocated in the spare area. Then, data is recorded in the new replacement cluster.

[00809] When a verify error occurs when data is recorded in the new replacement cluster in the spare area, a process for replacing the new replacement cluster with a further new replacement cluster in the spare area is repeated.

[00810] Figure 43 shows an exemplary procedure of the process performed in step S112 of Figure 8A. The steps shown in Figure 43 are performed by the drive control section 311 of the drive apparatus 310.

- [00811] (Step S1108) The drive control section 311 records data at a specific location in the user data area 108. In this example, the specific location is determined in steps S107 and S110 of Figure 8A.
- [00812] (Step S1109) The drive control section 311 determines whether or not the data recording for the user data area 108 has succeeded. Such determination is performed by, for example, above-described verify process. If the data recording has succeeded, the process proceeds to step S113 of Figure 8A. If it has failed, the process proceeds to step S1110.
- [00813] (Step S1110) The drive control section 311 records data at a specific location in the spare area (for example, the inner spare area 106 or the outer spare area 107). In this example, the specific location is determined by referring next available location information in the spare area which is included in spare area management information 1108.
- [00814] (Step S1111) The drive control section 311 determines whether or not the data recording for the spare area has succeeded. Such determination is made by performing, for example, above-described verify process. If the data recording has succeeded, the process proceeds to step S113 of Figure 8A. If it has failed, the process returns to step S1110. As such, the data recording for the spare area is repeated until the, data recording for the spare area succeeds.
- [00815] As described above, when there is a defective cluster in the user data area 108, at least a part of the inner spare area 106 and the outer spare area 107 is used as an area for recording a replacement cluster for replacing the defective cluster.
- [00816] Alternatively, at least a part of the inner spare area 106 and the outer spare area 107 may also be used as an area for recording data after update in pseudo-overwrite recording described below.

[00817] More specifically, when there is a defective cluster in the user data area 108 due to a verify error generated in the replacement recording in the pseudo-overwrite recording, at least part of the inner spare area 106 and the outer spare area 107 may be used as an area for recording data after update in pseudo-overwrite recording.

[00818] Hereinafter, an example of a specific process according to the data recording procedure is shown in Figures 34 and 43.

[00819] Figure 44A shows an exemplary data structure of the information recording medium 100 before the data recording shown in Figure 34 is performed.

[00820] In the example shown in Figure 44A, track #M 7000 and track #N 7100 are allocated to a user data area 108. In this example, the track #M 7000 is an open track which includes a recorded area 7003 including data "A" 7001 and an unrecorded area 7002.

[00821] The track #N 7100 is an open track including an unrecorded area 7102.

[00822] In the state shown in Figure 44A, it is assumed that the drive control section 311 receives a recording instruction from the host apparatus 305. In this example, it is assumed that the recording instruction is an instruction for recording data "A1" 7101 at a location of LSN=A0 (PSN=a0). In this example, the location of LSN=A0 (PSN=a0) is the location where data "A" 7001 has already been recorded. Thus, the recording instruction indicates pseudo-overwriting of data "A1" 7101 on the data "A" 7001.

[00823] The drive control section 311 records data "A1" 7001A at a specific location in the user data area 108 (step S1108).

[00824] In the example shown in Figure 45A, the data "A1" 7101A is recorded in a replacement cluster at a location of PSN=a1, which is a location of one NWA in the user data area 108.

[00825] In this case, the drive control section 311 determines whether or not recording of data "A1" 7101A to the replacement cluster at the location of PSN=a1 has succeeded (Step S1109).

[00826] If the recording has succeeded, the drive control section 311 generates replacement management information 7200 shown in Figure 45B. If it has failed, the drive control section 311 records data "A1" 7101A at a specific location in the spare area (Step S1110).

[00827] In the example shown in Figure 46A, the data "A1" 7101A is recorded in a replacement cluster at a location of PSN=s1, which is a location in an inner spare area 106. In this case, the drive control section 311 determines whether or not recording of data "A1" 7101A to the replacement cluster at the location of PSN=s1 has succeeded (Step S1111).

[00828] If the recording has succeeded, the drive control section 311 generates replacement management information 7201 shown in Figure 46B. If it has failed, the drive control section 311 records the data "A1" 7101A at a specific location in the spare area.

[00829] Until data recording to the spare area succeeds, data recording to the spare area is repeated. Thus, the number of times of replacement recording cannot be previously known.

[00830] Thus, in the case where the drive apparatus 310 receives one recording instruction from the host apparatus 305, the drive apparatus 310 may perform replacement recording for a plurality of times. In such a situation, the replacement

recording for the second time and the following replacement recording are not expected by the host apparatus 305.

[00831] As described in Embodiment 4 and the like, there is a problem that when the replacement recoding which is not expected by the host apparatus 305 is performed by the drive apparatus, the size of replacement management information list 1000 is increased.

[00832] In the present embodiment, when the replacement by the pseudo-overwrite is performed for the NWA of an open track and a verify error occurs; the subsequent replacement recording is performed for the spare area.

[00833] In this way, the replacement recording in the user data area which is not expected by the host apparatus 305 does not occur.

[00834] Thus, even when the host apparatus 305 continuously issues recording instructions, the size of the replacement management information list does not increase.

[00835] When the verify error occurs, by allocating the replacement location in the spare area (not in the user data area), it is possible to reduce time required to determine the NWA.

[00836] If the replacement location is allocated in the user data area, it is not determine the latest NWA until the verify process is successfully completed after the data is recorded at the NWA.

[00837] This is because the NWA must be updated repeatedly until the verify process is successfully completed after the data is recorded at the NWA.

[00838] On the other hand, according to the present invention, the NWA is determined at the time when it is determined to perform the pseudo-overwrite recording. Thus, the drive apparatus 310 can return the latest NWA to the host

apparatus 305 without causing any time delay in response to a request from the host apparatus 305.

[00839] In the above description, an example in which track #M 7000 is an open track has been described. However, the track #M 7000 may be a closed track. Further, the location indicated by the recording instruction may be included in the unrecorded area 7002. In either case, steps S1118-S1111 shown in Figure 43 are performed as described above.

[00840] In each of the embodiments, any of replacement management information 1010 shown in Figure 5B, replacement management information 1010B shown in Figure 11, and DFL entry 2010 shown in Figure 16 may be used as replacement management information.

[00841] The replacement management information includes at least original location information 1012 (or, defective cluster first PSN 2012), and replacement location information 1013 (or, replacement cluster first PSN 2013).

[00842] Furthermore, irrespective of the purpose of the replacement (replacement due to defectives, or replacement due to pseudo-overwrite), the same replacement management information can be used. In this way, regardless of the purpose of the replacement, and/or types and locations of the replacement locations, the pseudo-overwrite recording method can be realized by the replacement management information having a single type structure.

[00843] Thus, when data is reproduced from the information recording medium 100 in which the data is pseudo-overwrite recorded, it becomes possible to reproduce data using the same process without paying attention to the purpose of the replacement, and/or types and locations of replacement locations. This enables the drive apparatus 310 to be readily implemented.

[00844] In the replacement location information 1013 (or, replacement cluster first PSN 2013) of the replacement management information, a physical address which indicates a specific location of the user data area 108 is set when the replacement for the purpose of the pseudo-overwriting recording occurs, and a physical address which indicates a specific location of the spare area (for example, inner spare area 106 or the outer spare area 107) is set when replacement for the purpose of recording due to defect occurs.

[00845] Therefore, a range of the physical address to be set in the replacement location information 1013 (or, replacement cluster first PSN 2013) of the replacement management information when the replacement for the purpose of the pseudo-overwriting recording occurs is limited to a range of the user data area 108 (hereinafter, also referred to as a first range). Further, a range of the physical address set in the replacement location information 1013 (or, replacement cluster first PSN 2013) of the replacement management information when the replacement for the purpose of recording due to defect occurs is limited to a range of the spare area (hereinafter, also referred to as a second range).

[00846] Thus, it is possible to generate replacement management information having a single structure while maintaining information on the purpose of the replacement. The replacement management information can be used for the purpose of recovering an error when the error occurs in reproducing data from the replacement cluster.

[00847] When the replacement management information indicates the replacement for the purpose of recording due to defect, it is determined that data which is the same as the data recorded in the replacement location is recorded at the original location. By reproducing data from the original location, there is a possibility that

correct data may be reproduced. When the correct data is reproduced, it is possible to avoid the occurrence of a reproduction error.

[00848] (Embodiment 8)

[00849] In the present embodiment, a procedure for selecting recording location of a replacement cluster in replacement recording will be described with reference to Figure 47.

[00850] Figure 47 shows exemplary spare area, track structure, states of unrecorded area in the information recording medium 100 according to the present invention.

[00851] The information recording medium 100 includes an inner spare area 106, outer spare area 107 and unrecorded areas 601A and 601B thereof.

[00852] Further, information recording medium 100 includes track #1 8610 (open), track #2 8620 (open), and unrecorded areas 8612 and 8622 thereof.

[00853] Thus, the information recording medium 100 includes a plurality of recording locations of replacement clusters.

[00854] In the present embodiment, the user data area is preferentially used as recording locations of the replacement clusters when the size of the unrecorded areas in the spare area satisfies predetermined criteria.

[00855] More specifically, for determining the recording locations of the replacement clusters, the size of the unrecorded areas in the spare area at the moment is obtained from disc structure information 1100.

[00856] Then, it is determined whether the size of the unrecorded area satisfies a predetermined criterion.

[00857] If the size of the unrecorded area satisfies the criterion, the user data area is selected as the recording location.

- [00858] The predetermined criterion is measured by, for example, whether the size of the unrecorded area is below a predetermined size, whether the size of the unrecorded area is below a certain percentage with respect to the total size of the spare area, or the like.
- [00859] When there is no unrecorded area left in the user data area, the spare area may be used as the recording location of a replacement cluster.
- [00860] Such a replacement cluster is recorded at a location indicated by, for example, next available location information 8600A in Figure 47.
- [00861] In general, in a file system such as UDF, specific information (for example, a data structure called LVID) has to be updated when the information recording medium 100 is closed.
- [00862] When there is no unrecorded area left in the user data area, user data cannot be added anymore. Thus, a closing process for the information recording medium 100 is performed.
- [00863] According to the present embodiment, an unrecorded area is left in the spare area even in such a state. Thus, it is ensured that information such as LVID is recorded.
- [00864] On the contrary, if the spare area is used first, LVID cannot be recorded when the information recording medium 100 is closed. Thus, the closing process becomes impossible.
- [00865] In other words, one effect of the present invention is that the closing process can be performed surely.
- [00866] Of course, the above description can be applied to both replacement recording of defective clusters and pseudo-overwrite recording.
- [00867] (Embodiment 9)

[00868] In the present embodiment, a procedure for selecting recording locations of replacement clusters in replacement recording will be described with reference to Figure 48.

[00869] In Figure 48, original location 9650 is a defective cluster, and replacement recording having the location as the original location is performed.

[00870] At this time, the replacement location is determined by a following procedure.

[00871] In Figure 48, the replacement locations in which replacement clusters can be recorded are an unrecorded area 9601A (in the inner spare area 106), an unrecorded area 9612 (in a track 9610), an unrecorded area 9622 (in a track 9620), and an unrecorded area 9601B (in the outer spare area 107).

[00872] In this example, a certain range from the spare area 106 is denoted by D1.

[00873] In the present embodiment, when the original location cluster is within the range of D1, the replacement location is the inner spare area 106.

[00874] Similarly, a certain range from the outer spare area 107 is denoted by D4.

[00875] In the present embodiment, when the original location cluster is within the range of D4, the replacement location is the outer spare area 107.

[00876] The original location 9650 is at a distance of D2 from the inner spare area 106. When $D1 > D2$, the replacement location of the original location 9650 is determined by the spare area 106.

[00877] At this time, the replacement cluster is recorded at a location indicated by, for example, next available location information 9600A shown in Figure 48.

[00878] As the original location 9650, the unrecorded area 9612 can also be used. However, one of the features of the present invention is not use the unrecorded area 9612 since the original location 9650 is within a predetermined range D1 from the inner spare area 106.

[00879] On the other hand, the original location 9651 of Figure 48 is at a distance D3 from the inner spare area 106, and $D1 < D3$. Thus, the replacement location of the original location 9651 is not the inner spare area 106. Similarly, it is not replaced to the outer spare area 107.

[00880] In this example, original location 9651 is replaced within the user data area, for example, the unrecorded area 9622 or the like. Specifically, even there is an unrecorded area in the inner spare area 106 or the outer spare area 107, it is not used if it does not satisfy the above-described conditions regarding the range. This is one of the features of the present embodiment.

[00881] With such a procedure for selecting replacement locations, a header portion of a volume space is preferentially replaced to the inner spare area 106, which is an inner part of the information recording medium 100. Further, an end portion of the volume space is preferentially replaced to the outer spare area 107, which is an outer part of the information recording medium 100.

[00882] In general, in a file system such as UDF, volume structures, information which may be a starting point of directory structures (for example, FSD, ROOT directory and the like), space bit maps and the like are located in the header and end of the volume space.

[00883] These data are often read first when the information recording medium 100 is read out, and frequently accessed.

[00884] According to the present embodiment, these data are collectively located in the spare area. Thus, it becomes possible to improve the recording/reproduction property of the data.

[00885] In this embodiment, replacement recording of defective clusters has been described. However, the above description can also be applied pseudo-overwrite recording, which is also replacement recording.

[00886] (Embodiment 10)

[00887] In the present embodiment, the data recording procedure will be further described.

[00888] Figure 49A is a figure showing exemplary data structure of the information recording medium 100 before data recording according to the present embodiment is performed.

[00889] In Figure 49A, track #N-1 10000 and track #N 10010 are allocated.

[00890] In the track #N 10010, entire area is an unrecorded area 10003. Further, the track #N 10010 is located at the end of the user data area.

[00891] In a conventional recording method, a new track can be allocated at any location only in a track which is located at the end of user data area such as track #N 10010.

[00892] In the state of Figure 49A, the host apparatus 305 is assumed to instruct the drive apparatus 310 to record data "B" 10820.

[00893] In such a state, when the data "B" 10820 is instructed to be written to LSN=A2 (PSN=a2) in a conventional recording method by sequential recording, dummy data is recorded to immediately before PSN=a2, and then the data "B" 10820 is recorded.

[00894] Data can be recorded in this method, but there is a problem that the capacity of the information recording medium 100 is wasted by recording dummy data. Particularly, when PSN=a2 is close to the end of the user data area, a very large area of the user data area is wasted.

[00895] Alternatively, as shown in Figure 50A, a part of the track #N 10010 may be added as a track #N+1 10020, and then the data "B" 10820 is recorded from the header of the track #N+1 10020.

[00896] In this case, the user data area is not wasted, but since the track is allocated to the end of the user data area, there is a problem that further addition of tracks becomes impossible.

[00897] Thus, in the present embodiment, these problems are solved by employing the following recording method.

[00898] When a recording instruction is issued for a physical address larger than NWA in a track in which a new track can be added, the data is recorded in a replacement cluster.

[00899] Then, replacement management information 1010, which has the physical cluster which is specified by the recording instruction as the original location, and the replacement cluster to which recording is actually performed as the replacement location, is generated.

[00900] For example, Figure 51A shows exemplary data structure in which the replacement location is the outer spare management area 107.

[00901] In Figure 51A, data "B" 10820B is recorded in the outer spare area 107. On the other hand, data is not recorded at the location of PSN=a2 in the track #N 10010, i.e., the location specified by the recording instruction from the host apparatus 305. Thus, LRA 10030A is not updated.

[00902] At this time, in replacement management information 10817 to be generated, as shown in Figure 51B, PSN=a2 is set in the original location information 1012, and PSN=s2 is set in replacement location information 1013.

- [00903] As described above, PSN=a2 corresponds to the location which is specified by the recording instruction from host apparatus 305. On the other hand, PSN=s2 is the location where the data "B" 10820 is actually recorded in the outer spare area 107.
- [00904] By generating such replacement management information 10817, it becomes possible to reproduce the data "B" 10820 from PSN=s2 when the host apparatus 305 issues a reproduction instruction to LSN=A2.
- [00905] Similarly, in Figure 52A, data "B" 10820C is recorded at a location of NWA 10011A of the track #N-1 10000 which can be recorded. In accordance with such recording, LRA 10010A is updated to LRA 10010C.
- [00906] In such a state, in replacement management information 10818 to be generated, as shown in Figure 52B, PSN=a2 is set in the original location information 1012, and PSN=b1 (a physical address corresponding to NWA 611A) is set in the replacement location information 1013.
- [00907] Further, since the logical cluster corresponding to PSN=b1 becomes an unrecorded cluster, replacement management information 10819, which has PSN=b1 set in the original location information 1012 and 0 set in replacement location information 1013, may be provided.
- [00908] By generating such replacement management information 10818, it becomes possible to reproduce the data "B" 10820C from PSN=b1 when the host apparatus 305 issues a reproduction instruction to LSN=A2.
- [00909] By reproducing replacement management information 10819, it becomes possible to return data of, for example, all 0, without reproducing the data "B" when the host apparatus 305 issues a reproduction instruction to LSN corresponding to PSN=b1.

[00910] In both examples shown in Figure 51A and 52A, an area used in the information recording medium 100 corresponds to the size of the data "B" 10802 which is instructed to be written, and ineffective recording of dummy data or the like is not necessary.

[00911] Further, since data is recorded without adding a new track, further addition of a track to the track #N 10010 can be performed without restraint.

[00912] As described above, in a track in which a new track can be added, even when data is instructed to be written in a location having an address larger than NWA, it is possible to perform data recording which does not cause a recording error, is efficient, and does not prohibit the later addition of a new track, by performing replacement recording using replacement management information.

[00913] Further, Figure 53A is a illustrative diagram showing a data structure when data is further recorded to track #N 10010 from the state as shown in Figure 52A, recorded area 10840 is formed, and then, data "C" 10842 is recorded in an ECC cluster (PSN=c1) immediately before PSN=a2.

[00914] In this example, a verify process after recording of data "C" 10842 detects that the ECC cluster of PSN=c1 is a defective cluster 10841. As a result, the data "C" 10842A is recorded in an ECC cluster of PNS=a2 instead of the ECC Cluster of PSN=c1.

[00915] In order to reflect such replacement recording, the replacement management information 10820 shown in Figure 53B is provided. The original location of the replacement management information 10820 is PSN=c1, and the replacement location is PSN=a2.

[00916] In the state as shown in Figure 52A, data is not recorded at PNS=a2. However, as shown in Figure 53A, after sequential data is recorded by sequential

recording, data is recorded in such areas, and the user data area can be effectively used.

[00917] (Embodiment 11)

[00918] In the present embodiment, the data recording procedure will be further described.

[00919] In conformity to UDF specification, the recording procedure will be described with reference to an exemplary process of a format process for file systems will be described.

[00920] Figure 54 is a diagram showing an exemplary correspondence between a logical address space and a physical address when replacement recording is not performed.

[00921] Figure 54 also shows location of data included in a volume structure area 410 defined by the UDF specification.

[00922] A format process for file systems refer to a process of recording management information including data of these volume structure area 410, metadata files 440 within a partition space, and the like.

[00923] Conventionally, the file system first generates the file management information by a memory circuit 302 or the like with assuming the state as shown in Figure 54, and then record in the information recording medium 100.

[00924] When recording is actually performed, for example, as shown in Figure 55, a defective cluster may occur halfway, and replacement recording may be performed.

[00925] In accordance with such replacement recording, all the subsequent data has to be recorded at the replacement location.

[00926] This increases the size of the replacement management information list 1000.

[00927] One of the methods to avoid such a situation is to perform replacement recording of the defective cluster at PSN=1292 to the spare area.

[00928] However, the volume structure area 410 and/or metadata file 440 have to be read first in order to access the user data in the information recording medium 100.

[00929] If such data are dispersed in the spare area, it takes a long time for starting reproduction of the user data, which results in inconvenience for users.

[00930] Another method for avoiding is to change the data in the file management information, and change the logical address of the recording location. More specifically, when the recording location is shifted due to replacement recording, the amount of shift is adsorbed by changing the recording location of the file management information. Thus, it is no longer necessary to perform replacement recording.

[00931] However, for performing such a process, it is required to generate the file management information which has been established at the start of the format process again. This makes the file system more complicated and increases the process time.

[00932] Thus, in the present embodiment, these problems are solved by the following recording method.

[00933] As shown in Figure 56, when data included in the volume structure area 410 is recorded, a predetermined number of reserved clusters 9000 are reserved between an anchor volume descriptor pointer 703 and the rest of the data, and performs the format process for the file system.

[00934] In the reserved clusters 9000, valid data is not recorded at initial state. However, they are used as replacement clusters when there is a failure in the verify process when the volume structure area 410 is recorded.

[00935] In the present embodiment, a volume recognition sequence 700, a main volume descriptor sequence 701 and a logical volume integrity sequence 702 are sequentially recorded by a verify-after-recording process.

[00936] When there is a failure in the verify process, replacement recording is performed to a reserved cluster 11000.

[00937] In Figure 56, for example, PSN=1132 is a defective cluster, and its replacement location is at PSN=1164. Subsequently, replacement recording of the logical volume integrity sequence 702 is also performed. However, by reserving a plurality of the reserved clusters 11000, anchor volume descriptor pointer 703 and the following partition space 710 can be recorded at PSN=1356 without shifting the recording locations.

[00938] Further, in the present embodiment, backup recording of the anchor volume descriptor pointer 703 is performed in the reserved cluster 11000.

[00939] Backup recording of the anchor volume descriptor pointer 703 is to record the data having the same contents as the anchor volume descriptor pointer 703 before the actual recording of the anchor volume descriptor pointer 703.

[00940] In Figure 56, recording to PSN=1292 and 1324 is backup recording.

[00941] Effects of performing backup recording are as follows.

[00942] If the recording of the anchor volume descriptor pointer 703 to the PSN=1356 fails, replacement recording is required.

[00943] At this point, if the replacement management information 1010 which designates PSN=1292 or 1324 which has been backup-recorded as the replacement location is generated, anchor volume descriptor pointer 703 is recorded at the replacement location, and any address shift is caused from PSN=1356.

- [00944] As for the file management information, the replacement location and the original location are very close, and access time for reproduction can be reduced.
- [00945] Further reserved cluster 11000 may be provided between the anchor volume descriptor pointer 703 and the header of the partition space 710.
- [00946] As described above, the present embodiment can realize a fast access to the file management information, and further prevent replacement management information 1010 from occurring in the format process of the file system in conformity to the UDF specification.
- [00947] Special replacement management information 1010 for associating the reserved cluster 11000 to a specific recorded cluster may be defined.
- [00948] More specifically, new flag which indicates that it is special replacement information may be provided in status information 1011 of replacement management information 1010.
- [00949] Then, PSN of recorded cluster is set in the original location information 1012. On the other hand, PSN of the reserved cluster 11000 is set in the replacement location information 1013.
- [00950] For example, association of unrecorded reserved cluster 11001 to the logical volume integrity sequence 702 at PSN=1196 becomes possible.
- [00951] For this unrecorded cluster, data is allowed to be recorded only when pseudo-overwrite recording of the recorded cluster associated by the replacement management information 1010 is performed.
- [00952] With such an association, pseudo-overwrite recording of a certain recorded cluster in future is ensured.

[00953] For example, the logical volume integrity sequence 702 has to be recorded at last in the information recording medium 100 formatted in accordance with the UDF specification.

[00954] Therefore, by associating the specific recorded cluster and the reserved cluster, the pseudo-overwrite recording thereof is ensured.

INDUSTRIAL APPLICABILITY

[00955] The present invention is useful, since it provides a drive apparatus and the like capable of utilizing the user data area without any loss in the pseudo-overwrite recording for the write-once optical disc.